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ECONOMIC ANALYSIS OF RANGE IMPROVEMENT

A Guide for Western Ranchers

C. O. McCorkle, Jr. and D. D. Caton

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California Agricultural Experiment Station in cooperation with
Farm Economics Division, Economic Research Service,
U. S. Department of Agriculture

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ECONOMIC ANALYSIS OF RANGE IMPROVEMENT
A GUIDE FOR WESTERN RANCHERS

C. O. McCorkle, Jr.[1] and D. D. Caton[2]

INTRODUCTION

The primary purpose of this report is to consider and illustrate a method that can be used to evaluate range improvement. An appreciation of economic principles will help ranchers select profitable range improvement practices. Questions about the profitability of practices and similar questions are considered through discussion and illustration. The contents of this report include: (1) a description of the western range and its use, (2) an explanation and example of how physically different rangelands are combined to form a ranching operation, (3) the major feed procurement and utilization problems of ranching operations, (4) the present and potential place of range improvement practices in solving these problems, and (5) the economic principles and framework of analysis for evaluating range improvement.

Grazing management has developed from the first stage when emphasis was on exploitation to the present emphasis on intensive management. While more intensive management of rangelands may reflect increased awareness on the part of ranchers about management, probably of greater importance is the fact that better management has paid. Ability to pay is a direct guide to the selection of practices, but the inducement to consider new practices can also come from such sources as competition in the market, federal land adjustment policies, cost increases, and changes in the factors employed in production.

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Research by public and private agencies has developed possible ways of improving grazing capacity. New grasses and new ways of improving range have been developed, and efforts in this direction will be continued. It is possible for ranchers to increase, stabilize, and to adjust the time distribution of feed supplies. Analyses of costs and benefits of range improvement are also providing the necessary interpretive information.[3]

WESTERN RANGELANDS

The western range is the aggregate of the public and private dryland forage areas of the western states and of the western portions of the Great Plains states (figure 1). Within this grazing area there are nine[4] physiographic types: (1) Northern Great Plains, (2) Southern Great Plains, (3) Mountain, (4) Intermountain, (5) Southern Intermountain, (6) Southern Desert, (7) Southwestern Desert, (8) Northwest, and (9) California.[5]

Tangible salable products of the western range are timber, minerals, forage, and livestock products. Other values include recreation and scenic values and wildlife and watershed values. Since a range area seldom has a single use, there are problems in allocating the resources among the possible demands.

The importance of the western range to the agriculture of the twelve western states including Hawaii is indicated by the major uses of land.

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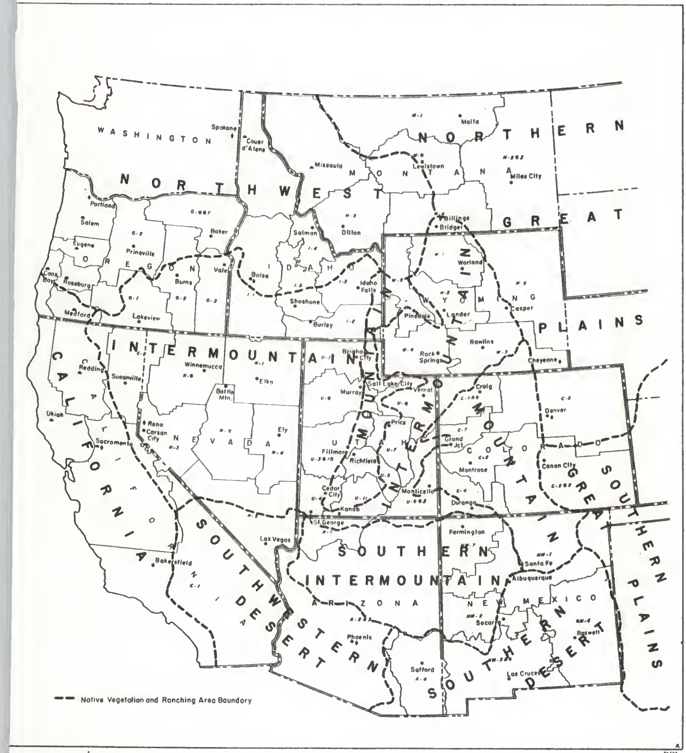
[3] Results of this research are summarized in a forthcoming publication (by the authors of this report) which examines methods, costs, and returns in improving western rangelands. Also, individual states in the west have published findings of their contributing projects to the western regional research program on the economics of improving western rangelands.

[4] Hawaii may be classed as a tenth type.

[5] Several variations of this classification are used. For example, see Clawson, Marion, The Western Range Livestock Industry, McGraw-Hill, 1950, p. 28.

FIGURE 1

Native Vegetation and Ranching Areas of
the Western States (excluding Hawaii)



Source: Bureau of Land Management

One-half or more of the land area of the states of Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, and Nevada are nonforested pasture and grazing lands (table 1). Substantial areas of the forested lands of these states are also used for grazing. In the eleven western states, over 610 million of the 750 million acres of total land area are grazed during a part of the year.[6] Of Hawaii's 4 million acres about 1 million acres are grazed. Pasture, open grazing land, hay, and other feeds are the basis of the livestock economy which dominates the agriculture of the West.

On January 1, of the years 1955-59, there was an average of 9,137,000 cattle other than milk cows and 10,310,000 sheep and lambs on farms in the eight western states other than the Pacific Coast states and Hawaii.[7] Comparable numbers for the three Pacific states were 4,137,000 cattle and 3,089,000 sheep and lambs and for Hawaii 161,000 cattle and 11,000 sheep and lambs. Data for the Mountain states more clearly reflect the product of the range areas because a greater number of livestock in these states are produced on range forage. In the Pacific Coast region, more of the livestock are in feedlots or on irrigated farms.

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[6] Excluding the 61 million acres of cropland, the remainder of the total land area is either densely forested, as in much of northern Idaho and western Washington, completely barren, as in the salt flats of Utah, or in public parks or other areas where grazing use is restricted.

[7] Compiled from U. S. Agricultural Marketing Service, Livestock and Poultry Inventory, January 1, Number, Value and Classes. Annual issues, Washington, D. C.

TABLE 1

Major Uses of Land, by Regions and States, 1954

State and region	Approximate land area	Cropland		Pasture and grazing land nonforested		Forest and woodland		Special and miscellaneous uses	
		Acreage	Percentage of total area	Acreage	Percentage of total area	Acreage	Percentage of total area	Acreage	Percentage of total area
	1,000 acres	1,000 acres	percent	1,000 acres	percent	1,000 acres	percent	1,000 acres	percent
Oklahoma	44,180	14,774	33	16,203	37	10,289	23	2,914	7
Texas	168,648	37,346	22	88,150	52	32,810	20	10,342	6
Southern Plains	212,828	52,120	25	104,353	49	43,099	20	13,256	6
North Dakota	44,836	27,872	62	13,300	30	551	1	3,113	7
South Dakota	48,983	19,692	40	24,764	51	2,133	4	2,394	5
Nebraska	49,064	23,269	47	22,542	46	1,080	2	2,173	5
Kansas	52,549	30,210	58	17,796	34	1,664	3	2,879	5
Northern Plains	195,432	101,043	52	78,402	40	5,428	3	10,559	5
Montana	93,362	15,005	16	54,742	59	19,803	21	3,812	4
Idaho	52,972	5,540	10	25,766	49	17,410	33	4,256	8
Wyoming	62,404	2,582	4	48,484	78	7,720	12	3,618	6
Colorado	66,510	11,257	17	33,237	50	19,523	29	2,493	4
New Mexico	77,767	2,504	3	50,178	65	20,369	26	4,716	6
Arizona	72,688	1,615	2	44,838	62	18,412	25	7,823	11
Utah	52,701	2,037	4	27,577	52	15,409	29	7,678	15
Nevada	70,265	678	1	46,070	66	11,509	16	12,008	17
Mountain	548,669	41,218	8	330,892	60	130,155	24	46,404	8
Washington	42,743	7,710	18	7,628	18	21,576	50	5,829	14
Oregon	61,642	5,282	9	25,561	41	28,931	47	1,868	3
California	100,314	13,251	13	26,661	27	39,398	39	21,004	21
Pacific	204,699	26,243	13	59,850	29	89,905	44	28,701	14
Hawaii	4,100	308	8	1,384	34	1,045	25	1,363	33

Sources: U. S. Department of Agriculture, Agricultural Research Service, Major Uses of Land in the United States, Summary for 1954, Agricultural Information Bulletin No. 168, January 1957, Washington, D. C., p. 60. Statistics of Hawaiian Agriculture 1959, Agricultural Economics Report No. 46, University of Hawaii, Honolulu, Hawaii, June 1960.

Physical Characteristics of the Western Range

The principal contribution of the western range to the livestock economy is forage. Productivity differs considerably from area to area and a considerable difference in the productivity of the ranges can be expected from year to year. Each year's forage production reflects annual and seasonal precipitation, temperature, elevation, soil type, topography, and the previous grazing history. Climatic conditions, topography, soil and elevation are the main factors which determine area differences, and climatic changes are the main factors which determine year to year differences in forage production. The western range is in three distinct climatic zones: (1) the winter precipitation zone, characteristic of California, where rainfall is concentrated in the December-March period with almost no rain during the months of July and August, (2) the spring precipitation zone, as found in the Northern Great Plains, where rainfall is heaviest in the April-June period, and (3) the late summer precipitation zone, characteristic of Arizona and New Mexico.[8/] The western region west of the Rocky Mountains has a fall-winter-spring precipitation pattern and the area east of the Rocky Mountains has a spring-summer precipitation pattern.

Precipitation requirements for forage production are related to humidity, temperature, and wind velocity. Most of the western region has low humidity, portions of the West Coast and Hawaii being the major exceptions. Temperatures are influenced by latitude and elevation. The frost-free period also influences the kind of grasses and growth characteristics of these grasses. With the exception of a few areas along the Pacific Coast, in the southwest, and

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[8/] Stoddart, Lawrence A., and Arthur D. Smith, Range Management, McGraw-Hill, 1943, p. 52.

in Hawaii, the growing season for the range area is limited. At higher elevations the average frost-free period extends only from the latter part of May to early September.[9] In the Rocky Mountain regions elevations in excess of 6,000 feet typically have growing seasons of less than 90 days. Precipitation immediately prior to and during the grazing season and for the previous year have the greatest effect on the current year's growth. The important features of soil which affect plant growth are the ability of the soil to furnish nutrients to plants and the soil's ability to absorb and retain moisture.

The present density and composition of range forage is in part a reflection of the grazing history. Utilization practices have a significant influence on productivity. Out of recognition that forage production is so strongly influenced by use, a concept of "normal use" has evolved. Normal use establishes the grazing rates for forage types at levels which will maintain and provide for their reproduction. However, short-run departures from normal use are occasionally profitable. Sustained use over normal levels usually requires a program of periodic plant re-establishment. Excessive grazing typically results in loss of plant vigor and reproductive capabilities and decline or disappearance of the more palatable forage plants.

Seasonal grazing[10] is the dominant utilization program; the major types are (1) spring-fall, (2) winter, (3) spring-fall-winter, (4) summer, and (5) yearlong. A given range site may be used in one or more seasons of the year, or yearlong. A common practice is to have different ranges or pastures to fill out the annual forage need. Where two or more range areas with differing seasons of use are combined to provide forage, the system of livestock operation and the distance between feed sources are additional factors affecting seasonal use. The time period over which forage is available will influence the organization and the size of the livestock operation.

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[9] For a discussion of the effects of climate on range forage production see Clawson, Marion, The Western Range Livestock Industry, McGraw-Hill, 1950, pp. 32-44.

[10] Generally coincidental with the rainfall and temperature patterns which control forage growth. An important exception is the Plains area and Southwest where grasses cure and remain an important source of feed during the dry season.

Adaptation of Livestock Ranching to Physical Characteristics

The physical and climatic environment determines the feeding and the grazing program. In each physiographic area the rancher selects the livestock system and production practices that are compatible with the physiographic characteristics and with his capital and his managerial abilities, and with the institutions of the area. While the profitability of a ranching operation depends to a considerable extent on the ability of the manager, the environmental and institutional conditions set the limits on total production.

Range livestock operations conform closely to the physical characteristics, the seasonality of forage supplies, and the forage, feed, and water supply limitations of each environment. Favorable economic conditions permit some deviation from established patterns of production. More feed and livestock may be purchased, ranges cleared of brush and seeded, fences built and water developed, but the values created from possibilities must still be judged and compared against their cost and to the limitations imposed by the complementary forage and feed supplies to which they are related in the course of the annual livestock production period. The main vegetative types of the nine native vegetation areas of figure 1 are:[11/] (1) Northwest - coniferous forest, bunch grass, northern desert shrub, pinion-juniper, (2) Northern Great Plains - short grass, coniferous forest, tall grass, (3) California - bunch grass, coniferous forest chaparral, (4) Intermountain - northern desert shrub, pinion-juniper, bunch grass, short grass coniferous forest, chaparral, (5) Mountain -

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[11/] Predominant types underlined. This classification was furnished by Myrvin Noble, Range Conservationist, U. S. Bureau of Land Management, U. S. Department of Interior.

coniferous forest, pinion-juniper, chaparral, northern desert shrub, short grass, (6) Southwestern Desert - southern desert shrub, chaparral, pinion-juniper, (7) Southern Intermountain - pinion-juniper, short grass, northern desert shrub, coniferous forest, desert grass, chaparral, (8) Southern Desert - desert grass, short grass, southern desert shrub, pinion-juniper, chaparral, coniferous forest, and (9) Southern Great Plains - short grass, tall grass.

The ranching areas of the western region, as to type of livestock system, as to kind of livestock raised, and as to grazing and feeding patterns and program, closely correspond to the distinctions in type of native vegetation. However, because of the additional influence of topography, elevation, latitude, and climate, some overlap of the primary vegetative areas exists when the western region is classified on the basis of types of ranching operations. Saunderson describes seven ranching regions: Northern Plains, Central Plains, Southern Plains, Rocky Mountain, Intermountain, Southwest, and Pacific.[12]

The Northern Plains Region extends from the Rocky Mountains to the eastern boundary of the range country and from the Platte River northward into Canada. This is a short grass-midgrass range area. The short grasses provide summer grazing. The midgrasses provide early spring forage and, with precipitation, forage in the fall. With favorable moisture conditions this grass association furnishes continuous grazing for a period of nine to ten months.[13] Supplemental winter feeding is required. Winter feed is provided by native hay, grain hay, and dry-land corn. Cattle production predominates in this region.

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[12] This classification provides detailed breakdown of the eastern and a portion of the western range area but fails to distinguish between the Northwest and California range types. For a detailed description of the resources and ranching operations in each of these areas see: Saunderson, Mont H., Western Stock Ranching, The University of Minnesota Press, 1950, pp. 3-55.

[13] The midgrasses are less tolerant to excessive use than the short grasses and are among the first to diminish in density under excessive use. With a decline of the midgrass, the range lacks seasonal balance.

The Nebraska Sand Hills are unique in the Northern Great Plains Region. These hills, covered with deep-rooted tall grasses, are some 15 million acres in extent. Because of the tall grass, which is a coarse forage grass, this area is primarily a cattle range. The tall grasses do not cure well on the range, as do the short and midgrasses, but they produce a good quality native grass hay.

The Central Plains Region is the area south of the Platte River, extending south to north Texas and northeastern New Mexico. Short grasses such as buffalo grass and various gramas predominate. These grasses are good forage grasses; they can tolerate rather heavy grazing for short periods, and they provide a good dry feed. The ranges in this region are used primarily during the spring and summer.

The decline of the prominence of the midgrasses which provided spring-fall feed has forced production adjustments in this region and in the Northern Great Plains. Seeded grasses, such as Western and Crested Wheatgrass, are being used to provide forage in the spring and fall, to obtain spring feed earlier and to extend the fall forage period. Fall sown wheat, dryland corn, grain sorghums, and sudan grass are used when range feed is unavailable. In some areas of the Central Plains Region, shifts have been made from cow-calf type operations to livestock operations more seasonal in nature.[14/]

The Southern Plains Region consists of the central and western portions of Texas and the southeastern part of New Mexico. The vegetative association is short grasses, semi-desert grasses, leguminous shrubs, and winter growing annuals. A range of this type when it is in good condition will furnish yearlong grazing for sheep and cattle.[15/] Because of high temperatures and low rainfall, the ranges of this region are intolerant of overuse. Many ranges of this region have been invaded by woody shrubs, low trees, cacti, and weeds.

[14/] This may be accomplished by adding stocker-feeders or substituting stocker-feeders for cows and calves, thus shifting to a highly seasonal operation.

[15/] Winter feed supplementation is common.

The Rocky Mountain Region extends southeasterly from the Canadian border through Idaho, western Montana and Wyoming, northern Utah, central Colorado, and north central New Mexico. Ranches in this region are located in the mountain valleys and foothills. The different zones of vegetation[16] determine the season of use, and the suitability of each range for sheep or cattle. The vegetation of the foothills is the bunchgrass type. However, large areas of brush-grass associations are common, and cheatgrass, a rapid growing spring annual, is a persistent invader of the bunchgrass ranges.[17] The higher elevation ranges are used during the summer months. Winter feeding period of four to five months is usual; consequently, the amount of hayland and pasture are an important part of the ranching operation. The major management problem is the integration of seasonal forage supplies with the deeded property hay and pasture.

The Intermountain Region extends north and south between the Rocky Mountains on the east and the Cascade and the Sierra Mountains to the west. Much of the area receives less than 8 inches of rainfall annually. When possible, irrigation is used to increase the amount of winter feed. The vegetative zones follow much the same pattern as is found in the Mountain Region. Because of the arid nature of the region and because of the considerable distances between ranges the impact of seasonality is even more pronounced than it is in the Mountain Region.

The Southwestern Region composed primarily of Arizona, the southwestern portion of New Mexico, and the southern region of California includes a large part of the drainage basins of the Colorado and the Rio Grande Rivers. The range cover is a mixture of creosote brush, desert shrubs, annual desert grasses and weeds at the lower elevations, and grama grasslands at the 4,000 to 6,000 foot level. Rainfall comes at two different periods of the year—winter and late summer. The national forests furnish summer range. The grama grasslands provide ranges which are capable of supporting livestock through the year, with occasional supplemental feeding. Precipitation, critical to the growth of range plants and in supplying irrigation water for the production of feed crops is highly variable, particularly at lower elevations.

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[16] Determined by rainfall, elevation, soils, and temperatures.

[17] Medusa Head, another spring annual, is also becoming a very serious problem.

The lower elevation ranges are used from late fall through spring. The livestock are then moved to ranges at higher elevations for the summer or are moved onto irrigated pasture.

The Pacific Region includes western Oregon and Washington and the area of California west of the Sierra and north of the Tehachapis. The range in this part of California consists primarily of annual grasses.[18/] Other areas of the Pacific are heavily timbered and of limited value for grazing. California's foothill areas are located on both sides of the Central Valley and along the coastal mountains. The range grasses grow abundantly in early spring but they dry quickly and by June they are of poor quality. Yearlong operations are limited by summer feed. Irrigated pastures, meadows, annual crops planted for grazing, and, to a limited extent, high summer ranges are used to augment the deficient summer forage. Sheep operations are based on fall or winter lambing with sale of fat lambs coinciding with the drying of the grass supply in April and May.

In Hawaii, pasture types and conditions vary greatly within a distance of a few miles.[19/] The plains and lower slopes on the leeward side of the islands

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[18/] Chaparral is a persistent invader, and dense stands of chaparral have reduced or eliminated grazing quite generally.

[19/] This description of Hawaii range and its use was adapted from a statement by Philipp, Perry F., University of Hawaii, Honolulu, Hawaii.

away from the prevailing trade winds are usually dry. Nonirrigated pastures in these zones provide winter grazing. A zone somewhat higher up the mountains, and in the lowlands on the windward side, with moderate rainfall and temperatures, provides year-round grazing. Zones near the crest of the lower mountains and at intermediate altitudes on the windward side of the highest mountains provide year-round grazing, but the forage is lacking in nutrients and palatability. A limited range area on the highest mountains furnishes good feed in late spring and summer.

Economic and Institutional Influences on Western Range Use

The concept of the supply of range forage, long considered in terms of its productive capacity in its native state, now includes the modifications that can be introduced through investment and management practices. The use and development of range forage can be and is modified as prices and costs change. In addition to increasing total forage production, range improvement practices can provide forage at an earlier date or over a longer season, a more palatable forage, or a more durable forage. With new opportunities available for increasing the physical and economic productivity of western rangelands, the early concepts of carrying capacity and of "use rates" must be broadened.

Two economic aspects of western ranching are particularly significant in specifying the role of range improvement and evaluating its effectiveness. The first of these is the size of operations and level of capital investment required in ranching. Practices which increase the forage production or the livestock output from a given forage supply directly increase the size and the intensity of the ranching operation. The second consideration is the variability in ranch incomes. Practices whose purpose is to stabilize output of forage and/or livestock product must be evaluated as to their effect on fluctuations in gross income.

The scale of western livestock operation is roughly established by the physical environment and the extent to which it can be modified. In areas such as the Intermountain and Southwestern Regions[20] where range productivity is low, more land per ranch is required than elsewhere. For example, the average size of ranches in Arizona and New Mexico in the Southwestern Region, and Nevada and Wyoming in the Intermountain Region is larger than in other states in the west (table 2).

Ranches in the Southwestern Desert and Southern Desert physiographic regions had twice as many animal units per ranch in 1954 and nearly twice as much in land and buildings on ranches as any other region (table 3). But in these regions, the proportion of ranches with annual sales of $5,000 or more (Census Economic Classes I-III) was only about one-fourth greater than in other regions. This relation is reflective of the low forage productivity of land in the desert and near desert type vegetation.[21]

Net incomes in the Southwest fluctuate much more than is true of other areas reflecting both variation in production and greater variation in feed purchases (table 4).

The physical characteristics of various areas of the west have greatly influenced the pattern of land ownership. In the Great Plains almost 90 percent of the grazing land is in private ownership. In the eight Mountain states, where much of the grazing land is relatively unproductive, over 50 percent of the area is publicly owned, and in the Pacific states public ownership accounts for 42 percent of the land (table 5). Over half of the range livestock of the west graze during a part of the year on federal lands.

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[20] The data on which these estimates are based were obtained from the Special Report, Western Stock Ranches and Livestock Farms, U. S. Census of Agriculture, 1954. These data are compiled by economic subregions, the boundaries of which correspond roughly, but not exactly, to the boundaries of regions of pp. 8-12.

[21] The year of record was a drought year, which would have an effect on the magnitude of productivity but still would not change the long-run relationship.

TABLE 2

Number and Average Size of Livestock Farms, Excluding Poultry and Dairy Farms, 11 Western States and Hawaii, 1954

State	Number	Average size	Percent of rate
		acres	percent
Arizona	1,866	9,706	20.1
California	10,363	2,010	8.4
Colorado	12,806	2,061	31.5
Hawaii[a/]	623	2,370	10.8
Idaho	4,883	1,254	12.6
Montana	10,668	3,551	32.4
Nevada	1,212	5,729	43.2
New Mexico	5,665	6,677	27.0
Oregon	6,085	1,943	11.2
Utah	4,544	1,824	19.7
Washington	4,289	1,019	6.6
Wyoming	5,890	5,023	51.9
AVERAGE		3,049.07	16.16

a/ 1950 for Hawaii.

Source: Western Stock Ranches and Livestock Farms, Special Report, Vol. III-Pt. 9, Ch. VI, 1954 Census of Agriculture, p. 8, for all states except Hawaii. Data for Hawaii from Vol. I Pt. 34, Ch. IV, pp. 15 and 23, 1950 Census of Agriculture.

TABLE 3

Investment, Sales, and Income Distribution per Ranch
in Selected Areas of the Western Region, 1954

Region	Animal units	Land and buildings	Livestock	Products sold	Distribution by economic class[a/]						Animal units in economic classes I-III
					I	II	III	IV	V	VI	
	number	dollars			percent						
Great Plains	161	70,653	13,198	9,772	8.5	15.8	20.7	22.8	21.0	11.2	80.6
Desert	311	132,071	29,066	37,644	19.3	18.1	17.5	16.4	20.3	8.4	91.7
Rocky Mountain	189	52,704	17,571	10,967	9.4	16.0	21.8	21.9	19.1	11.8	84.0
Intermountain	169	49,941	16,421	13,250	11.7	16.0	19.3	22.5	21.7	8.8	83.8
Pacific Coast	129	70,240	14,420	15,567	9.0	11.6	15.3	20.7	30.0	13.4	71.7

a/ Classification based on value of sales:

Class	Value of sales	Class	Value of sales
I	Over $25,000	IV	$ 2,500 - $ 4,999
II	$10,000 - $24,999	V	$ 1,200 - $ 2,499
III	$ 5,000 - $ 9,999	VI	$ 250 - $ 1,199

Source: Computed from data in Western Stock Ranches and Livestock Farms, Special Report, Vol. III Pt. 9, Ch. VI, 1954 Census of Agriculture, p. 8.

TABLE 4

Indexes of Gross Ranch Income, Net Ranch Income, Net Ranch Production, and Total Cost per Unit of Production, Selected Western Ranch Operations, 1937-41 Average, 1951-60 Annual

Type of ranch and location	Average 1937-41	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
	1947-49=100										
	percent										
Sheep ranches											
Northern Plains											
Gross ranch income	41	203	128	112	102	106	118	140	166	139	147
Net ranch income	40	280	85	77	62	63	88	158	192	118	117
Net ranch production	74	128	117	126	109	114	104	143	153	151	157
Total cost per unit	47	110	132	112	121	115	118	96	101	105	108
Southwest											
Gross ranch income	--	145	97	98	91	100	81	102	136	137	132
Net ranch income	--	201	25	15	18	63	14	116	217	207	193
Net ranch production	--	88	98	77	73	99	58	90	143	155	164
Total cost per unit	--	147	147	143	134	124	149	137	113	106	110
Cattle ranches											
Northern Plains											
Gross ranch income	29	158	112	95	90	82	71	93	114	109	105
Net ranch income	15	151	92	65	56	44	33	65	100	80	77
Net ranch production	62	108	110	114	113	105	97	107	104	93	106
Total cost per unit	56	119	126	114	112	118	124	118	129	149	139
Intermountain											
Gross ranch income	37	165	138	87	90	89	93	119	162	164	148
Net ranch income	34	167	127	61	52	53	66	97	151	145	110
Net ranch production	93	111	113	105	104	112	128	138	147	142	137
Total cost per unit	44	119	128	129	123	119	107	107	113	121	138
Southwest											
Gross ranch income	--	154	92	75	69	86	54	95	134	131	127
Net ranch income	--	162	20	- 9	6	55	-22	86	162	146	125
Net ranch production	--	97	78	86	80	97	61	103	124	134	146
Total cost per unit	--	136	167	142	147	149	126	122	126	124	127

Source: Columns 1 and 2, U. S. Department of Agriculture, Statistical Bulletin No. 197, November, 1956.

Columns 3 and 4, U. S. Department of Agriculture, Agricultural Information Bulletin No. 158, June, 1956.

Columns 5 and 6, U. S. Department of Agriculture, Agricultural Information Bulletin No. 176, June, 1957.

Columns 7, 8, and 9, U. S. Department of Agriculture, Agricultural Information Bulletin No. 230, June, 1960.

Columns 10 and 11, U. S. Department of Agriculture, Agricultural Information Bulletin No. 230, June, 1961.

TABLE 5

Ownership of All Pasture and Grazing Land, by Regions, Western Range Area, 1954 a/

Region	Public		Indian ownership		Private		Total	
	1,000 acres	per-cent	1,000 acres	per-cent	1,000 acres	per-cent	1,000 acres	per-cent
Northern and Southern Plains	10,248	6.9	5,514	3.8	132,035	89.3	147,797	100.0
Mountain	231,218	53.8	32,874	7.7	165,632	38.5	429,724	100.0
Pacific (including Hawaii)	44,891	41.9	3,647	3.4	58,680	54.7	107,218	100.0
TOTAL	286,357	41.8	42,035	6.2	356,347	52.0	684,739	100.0

a/ Computations from data presented in Major Uses of Land in the United States, U. S. Department of Agriculture, Agricultural Research Service, Agricultural Information Bulletin No. 168, p. 96, and Statistics of Hawaiian Agriculture, 1959, Ag. Econ. Report No. 46, University of Hawaii, June 1960.

Clawson and Held[22] identify five eras of federal ownership of lands which explain some of the changes and peculiarities of resource organization in western ranching. The first era was the period of acquisition of strategic sectors of land to protect the fur trade, establish boundaries, acquire harbors, and exclude foreign powers. The second era was the period of disposal when extensive efforts were made to transfer land from the federal government to state governments, local governments, and private owners. The third era covered the period of land reservation for special purposes. During this period the national forests and national parks were created. Federal areas not initially set aside remained as unreserved and unappropriated public domain until reserved under provisions of the Taylor Grazing Act in 1934.

The fourth era saw the establishment of the U. S. Forest Service in 1905 and the development of custodial management of public lands. Recognition of opportunities to increase the product of public lands through intensive management marks the beginning of the fifth and present era. The productivity of these lands is being increased through expenditures for roads, buildings, recreation facilities, and range and forest reseeding.

The Bureau of Land Management and the U. S. Forest Service administer most of the public lands used for the grazing of domestic livestock. The other public land agencies that administer some of these lands are the Office of Indian Affairs, the National Park Service, the Bureau of Reclamation, the Soil Conservation Service, the Fish and Wildlife Service, and various state and local agencies.

The grazing lands under the jurisdiction of the Bureau of Land Management are organized into grazing districts (other than isolated small tracts of land administered under Section 15 of the original Taylor Grazing Act of 1934) for better use and for purposes of administration. There are 59 organized Bureau of Land Management grazing districts; these districts contain 168 million acres of federally owned land and 97 million acres of land in other ownership. The number of livestock using the lands of the Bureau of Land Management since 1937 has been at between 2.5 and 3.7 million animal units. Total use in recent years has varied from 14 to 16 million animal unit months per year.[23] Eighteen million acres of Section 15 land furnishes about 2.5 million animal unit months of grazing each year.[24]

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[22] Clawson, Marion, and Burnell Held, The Federal Lands, John Hopkins Press, 1957, p. 16.

Except in Hawaii and in the case of Indian land, use of the public grazing lands is not determined by competitive bid. Certain conditions must be met by the livestock operator before he can obtain a lease or permit. Use is based on administratively set fees and on a quota system. Differences exist as to how the respective service agencies establish carrying capacity and set the level of the fee that is charged per animal unit. In recent years, however, the fee rate procedures used by the agencies are more nearly alike.

The Taylor Grazing Act which established the Grazing Service, now the Bureau of Land Management, merely specified that "reasonable" fees should be charged for the use of grazing land. At first no fees were charged.[25] Later a fee of 5 cents per head per month for cattle and one cent per head per month for sheep was established. In 1947 the grazing act was amended to base grazing fees on the cost of administration. By 1951 these fees had increased to 12 cents per head per month for cattle and 2.4 cents per head per month for sheep. The fee now charged is set to vary within limits in proportion to changes in livestock prices.

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[23] Ibid., p. 87.

[24] Ibid., p. 87.

[25] Ibid., p. 221.

The issue of public versus private ownership of public lands used for grazing, recreation, watersheds, timber production, and game production is not settled. Two areas of controversy can be identified.[26] The first concerns the products the public lands should be used to produce and how the products should be allocated to various groups of users. If privately owned, the production of the land tends toward salable commodities with the returns going to the owners. Services such as recreation or water storage are restricted and, if sold, the benefits are often concentrated in comparatively few hands. The issue is whether or not the value of a single product of the land (for example, livestock grazed) is worth more now and in the future to the general public than a multi-purpose use of the land. Establishment of values is extremely difficult. However, where multiple uses are, or can be, involved, the case for public ownership can usually be established.

A second area of controversy arises out of the different rates of use of natural resources devoted to alternative uses under private and public administration. When rates of use under private ownership seriously conflict with the interest of society, desirable changes in the use rate may be brought about by zoning, use of the taxing power, or other regulatory devices.

Of particular importance to range improvement and use in the West have been the influences of taxation and conservation payments. The possibility of an increase in property taxes on improved private holdings may deter improvement particularly for those areas near urban population centers. At the same time, income tax provisions have encouraged many ranchers to reinvest earnings in range improvement. Agricultural conservation funds have been of importance in encouraging land clearing and reseeding, soil and water conservation, and stock water development. Special funds have also been made available to eradicate noxious plants. The Soil Bank program has also encouraged improvement of grazing lands and the regrassing of cropland.

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[26] Ciriacy-Wantrup, S. V., Resource Conservation: Economics and Policies, University of California Press, Berkeley, 1952.

RANCH MANAGEMENT PROBLEMS AND THE ROLE OF RANGE IMPROVEMENT

Net income is the primary indicator of financial success. If total income exceeds total operating costs, the operator has obtained a return on his labor, management and equity. If the income is large enough to provide a going wage for him and his family's labor plus a market return on his equity in the ranch, the remainder is net profit. If a ranch is not making an adequate return low prices may be the primary cause but it may also be because of the way the ranch is operated. Levels of management and production efficiency are related to type, level and methods of production and their interrelationships.[27]

Major problems of a livestock ranch are the annual supply of feed and forage and the variation in the feed supply from year to year. But deficiencies and variations in feed supplies are not the same for all ranchers. The importance of the forage problem and the value of range improvement depends on the relationship between all of the ranch's resources and on their relationship to ranch management and ranch organization problems. The relationships between resources of the ranch may be simple or they may be complex; there are a multitude of practices which can be adopted and a multitude of changes in ranch organization that can result. The economic importance of adoption of practices or of changes in management is determined by how they affect income and distribution of income and costs over time.

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[27] Of primary importance is the average level of net income and how it is related to the financial needs. Year to year variability in net income is also of importance. Variations in gross income from year to year are the result of fluctuations in volume of sales (numbers and/or weights and prices received.)

The largest group of ranch management problems involves balancing seasonal feed resources to the needs of the livestock system. For example: the production of range forage on spring and fall ranges may be insufficient to carry the number of animals that can be carried by the summer and winter feeds. Unless the production of the spring-fall range is increased or unless feed or pasture is purchased, total production will be below that possible and seasonal forage will not be utilized.[28]

It may be possible to increase the carrying capacity of the spring-fall range. Brush species can be eliminated by spraying or by plowing, burning, or by other means.[29] Removal of brush is frequently followed by seeding of adapted grasses. The grasses may be selected on the basis of their growth characteristics or resistance to drought, volume of forage produced and so on. Many grasses have a number of characteristics which recommend them. Crested wheatgrass, for example, which has been planted to increase spring-fall range forage production, is also drought tolerant, a good producer, and when green, both palatable and nutritious. This early-growing, cool-season grass provides early-season grazing before native grasses have reached grazing height. A wide variety of clovers and grasses have been planted on California's foothill ranges to increase the length of the grazing season, increase the volume of feed, increase soil fertility and increase the protein in the forage diet. Summer grazing is increased by development of irrigated pastures, seeding of warm season grasses and improving range condition. A carryover of forage from the spring range may also be possible for later use.[30]

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[28] The overuse of the forage is not considered here.

[29] Often the improvement program consists of several treatment stages and the use of several treatment techniques. Chemical treatment followed by burning and later by spraying of regrowth and seedlings has been very effective. Detailed descriptions of range improvement practices are available in various references. (See bibliography).

[30] The forage is usually coarse and of lower nutritive value than when it is green. A protein supplement may be required. A shift of range use of this type may lower the overall capacity to produce livestock.

Fertilizers are used to increase forage production, lengthen the season of green feed availability, and encourage the growth of particular grass or legume species. Nitrogen has been used extensively on annual ranges in California to start early growth and to extend the green feed period, as well as to increase total forage production. Sulfur and phosphate fertilizers have been used to increase the growth of clovers and other legumes.

Inadequate production of winter feeds on many ranches leads to extensive purchases of expensive hay to carry the stock through the winter and early spring months. In many cases the land available to the rancher is not suited to hay production either because of soil conditions, topography, or moisture conditions. Shifts toward stocker and feeder operations with purchases and sales of livestock timed to the available feed have taken place in many such areas. In other instances the land resources for producing winter feed are available but for various reasons they have not been developed.

Four practices have been used to increase winter feed production. The two least expensive methods are fertilization and the planting of improved grass species. Native hay is still produced in some situations when grain hay or perhaps alfalfa could be grown. An opportunity often exists to increase the acreage of dryland hay production with relatively little capital outlay. If additional land can be farmed with existing equipment, small additional costs may be required. On occasion, water for irrigation can be obtained by diverting a stream or river or by developing underground sources. Irrigated pasture and hayland require a substantial capital outlay but they increase and add stability to the feed supply, and often make it possible to reduce the cash outlay for winter feed. Irrigation may also substantially improve the quality of the hay and pasture produced and permit more intensive fertilization and heavier rates of stocking.31/

31/ Hay and irrigated pasture are relatively high-cost feed unless the investment is nominal. More effective utilization is required.

The nutritional content of the forage supply is also a primary consideration. Management problems associated with the nutritional aspects of range forage are varied and difficult. Problems of this type are handled in the short-run by changes in management practices: by feeding and minerals, utilizing the feed at its optimum stages of growth, and insuring uniformity in the distribution of grazing. The longer term program may include production,more palatable and nutritious forage plants.

In addition to the problem of level and quality of forage production, the variation in forage production from year to year or season to season causes many management problems. The Southwestern Region is particularly noted for the wide fluctuations in grass production. Adjustments that have been made to highly variable feed conditions are: (1) selecting a mixed livestock system--stockers and cows and calves--to provide flexibility in adjusting livestock numbers to feed supplies, and (2) increasing the size of the operation to increase financial and feed reserves. The latter method is difficult for many ranchers to achieve because of the investment capital required. The first method merely means that animals that can be sold easily are carried in the herd.

Planting more drought-resistant species has been practiced. While helpful, this practice cannot be expected to solve the forage variation problem. Where hay is produced on the ranches, it is often possible to increase hay production and thus the reserve of stored seed. By fencing ranges and rotational grazing, the rancher may store additional feed on the range. However, extended drought usually causes serious distress in feed and forage supplies.

Range improvement and range management can solve some of the forage problems, and partially solve others. They can only minimize the effect of some problems such as prolonged drought. Range improvement has gone through wide swings in interest and popularity but since World War II, the interest has been sustained. During the drought periods of the 1930's ranchers became concerned about the declining productivity of western rangelands. The drought period of 1934-36, the most severe years of the drought period, accelerated the deterioration of the ranges and intensified concern. Reseeding received first attention. More integrated programs including fencing and crossfencing, control of poisonous plants, and water development followed.

At the start of World War II a combination of good weather, increased demand for livestock products, and rising prices diverted attention from range improvement. At the end of the war, emphasis again shifted to the long term forage supply needs and interest in improvement was renewed. During the 1949-51 period ranch incomes reached record levels, permitting substantial investments in range forage development. Ranchers became interested in lengthening the duration of seasonal forage supply and, if possible, in reducing year-to-year fluctuations in range forage production to maintain income. The success of public land improvement programs has also helped spread the interest in improving private rangeland. The technical assistance provided farmers by the Extension Service and by the Soil Conservation Service has also encouraged the use of improvement practices.

The anticipated growth in demand for livestock products is a further general impetus to increasing forage production and improving utilization. Population growth and changes in consumption habits are expected to require a 38 percent greater output of cattle and calves and a 14 percent increase in sheep and lambs by 1975 as compared to 1953.32/ Increased awareness on the part of the general public in conservation of natural resources and multiple-use of resources is also adding to the interest in improving and managing public and private lands used for grazing and other purposes.

32/ Barton, Glen T., and Robert O. Rogers, "Farm Output, Past Changes and Projected Needs," U. S. Department of Agriculture, Agricultural Research Service, Agricultural Information Bulletin No. 162, August 1956.

The extent of range improvement in the future will depend to a considerable degree on the availability of financial assistance. Aside from current ranching income, the main source of capital for improvement is private and public lending agencies. Some assistance comes from the government as payments for completing conservation practices. Governmental agencies administering public lands have spent and will continue to spend large sums of money to reseed and otherwise improve public lands used for grazing of domestic livestock by private ranches.

ECONOMIC ANALYSIS OF RANGE IMPROVEMENT

The nature of production problems faced by ranchers and the physical means of meeting them have been stated and briefly discussed. It is necessary now to develop an economic basis for an evaluation of range improvement. Although "demonstrations" of profitability of improvement practices are expressed in terms of returns less cost, reference to time, risk and uncertainty, and the rancher's capital position or preferences are also important. What is profitable for one rancher may not be profitable for another rancher. In other cases, more forage resulting from range improvement may require a series of adjustments including additional livestock, better management, more fences, additional stock water, more labor, and more capital. The extent of the changes that can be made can only be determined when the specific conditions of each case are known. Although it is impossible to take everything into account in this discussion, evaluation procedures can be given and illustrated.

For the sake of clarity and conceptual convenience, the range improvement programs to be considered in the following pages will be divided into two phases: improvement and utilization. While an improvement program may have several independent steps, each step is part of an integral process.

The removal of the existing vegetative cover and the seeding of a grass or grasses is a two-step process. Additional steps may be required; an example is the fencing of the seeded area for grazing protection. Costs may be direct--required by the practice--or indirect--caused by the practice. Fuel, seed, and labor are examples of direct costs. Indirect costs are income forgone, imputed interest on capital invested, and involuntary depreciation of other forage areas during the improvement period. Returns depend upon the kind and quantity of the product or products produced. Products are specified when the utilization program is selected.33/

Where range improvement changes the quantity or timing of the forage available for use, changes in utilization can also occur. Adjustments may include changes in the number of livestock grazed and timing and duration of the grazing period.

In planning for range improvement there are a number of essential points to consider. First, a need for additional forage for the existing livestock inventory or for a contemplated livestock inventory must exist, or it must be expected that range improvement will reduce other costs enough to make it worthwhile.34/ Second, range improvement must be possible by established technology or by management practices.35/ Third, the various levels of increases in forage or changes in the time and duration of the availability of the forage must be estimated. The costs and returns for alternative levels of increase or change in time the forage can be grazed can then be compared and each in turn can be compared with the present situation.

33/ Utilization is the transformation of forage into a livestock product. Where the product is in salable form, the estimated market price less marketing costs can be used directly in evaluating the contribution of the practice to net income. When the contribution is indirect, that is, when livestock are not immediately sold, evaluation of the net income effect requires more complex budgeting procedures.

34/ For example, the cost of purchased feed.

35/ The first two points are necessary conditions.

This evaluation must include all direct and indirect costs and all primary and secondary benefits. Fourth, the planned expenditures for the family and for capital outlays and the availability and cost of capital must be known in order to select the type and level of improvement program that would achieve all objectives.

Selecting and Evaluating Practices and Programs

The least complex problem of selection and evaluation practices from among alternatives arises when the final result is to be reached immediately and when alternatives are expected to yield approximately identical results. For example, if a rancher in Wyoming wishes to kill sagebrush he may spray the site with 2,4-D either by airplane or with ground application. The Appropriate procedure is a comparison of costs of the two methods and their relative effectiveness. A statement of the cost of each method will usually be sufficient.36/ The elements of this comparison are the physical inputs required and the costs of those inputs for each method. The data in table 6 are based on actual conditions but they should be considered primarily as an illustration of method.37/ Total costs per acre for air application are estimated at half those of ground application for the specific conditions in question. Assuming identical results, the choice would be air application.38/

Determining the least cost method of supplying stock water to a given pasture illustrates a slightly more complex question. Typical alternatives are to develop a spring, to drill a well, or to construct a dam and a stock water pond.39/ The following example also is a cost comparison, but in this

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36/ Assuming that the area to be sprayed can be completed by either method within the time period allowed and that the results are identical.

37/ Adapted from findings of Bohmont, D. W., Chemical Sagebrush Control, Wyoming Agr. Exp. Sta. Circ. No. 54, March, 1954, and Hyder, D. N., Spray to Control Big Sagebrush, Oregon Agr. Exp. Sta. Bul. No. 538, January, 1954.

38/ If timing and total time are factors, cost must be compared in terms of these factors.

39/ Also, water could be hauled.

TABLE 6

Comparative Costs Per Acre for Spraying a Big Sagebrush Range Area by Ground and Air Application

Ground application	(dollars)	Air application	(dollars)
Materials		Materials	
2 lbs. 2,4-D 10 gallons of water .05 gallons of liquid detergent	2.00	1-1/2 lbs. 2,4-D 5 gallons of water .025 gallons of liquid detergent	1.50
Application		Application	
Contract boom sprayer	4.00	Contract air application	1.50
TOTAL costs per acre	6.00	TOTAL costs per acre	3.00

case annual recurring costs must be included (table 7). A 2,500 acre pasture with carrying capacity of 124 head for four months is newly fenced for better grazing control. One way to secure stock water is to drill a well capable of delivering at least 2,000 gallons per day. This also requires a storage tank, a windmill, and a trough and float valve. Or a dam and a pond of approximately one and one-half acre-foot capacity could be built. Storage capacity of this amount is needed to allow for evaporation, seepage and the variation in annual rainfall.

The stock water dam is expected to last indefinitely provided the inflowing stream does not cause heavy silting. The well and curbing should also last indefinitely. But all other items for each method are depreciated since replacement is estimated to be required in twenty years. A rate of five percent has been used in estimating both depreciation and repairs.

The stock water dam is less costly to develop than the well. The annual costs also are somewhat less. If it is necessary to remove the silt occasionally, a periodic cost would be incurred. This could best be incorporated by estimating the cost to remove the silt and the length of time before the operation would be necessary, and expressing the ratio as an annual cost.

These examples are illustrative of practices applied in technically determined quantities with little reason for or opportunity to vary the "amounts" used. Many practices can be applied in increments, and these require additional economic evaluation. With practices that can be applied in relatively small increments, the question of the extent to which the practice should be applied must be considered. Fertilization of rangeland or supplemental feeding of livestock are examples. In principle, the variable inputs associated with a given practice are added to the point at which the added cost incurred by the inputs just equals the return

TABLE 7

Comparative Initial and Annual Costs of Providing Water for a 2,500-Acre Pasture by Two Methods a/

Stock water dam		Well development	
Initial Cost	(dollars)	Initial Cost	(dollars)
Dam construction		Well development	
600 cu. yds. fill @ $.70/yd.	420	Digging 4 feet x 30 feet	200
Spillway and drainage	125	Curbing and lining	75
Fencing, 1000 feet	140	Windmill, including tower	600
Pipe and trough installation	160	Fencing, 40 feet	6
		Storage tank, 20,000 gal. (used)	300
		Pipe and trough installation	160
TOTAL	845	TOTAL	1,341
Annual Cost		Annual Cost	
Maintenance and repairs	40	Maintenance and repairs	60
Depreciation	15	Depreciation	53
Interest on investment	42	Interest on investment	65
TOTAL	97	TOTAL	178

a/ Adapted from U. S. Department of Agriculture, "Stock-Water Development", Farmers Bul. No. 1859, July 1940.

added. The rancher needs to estimate the addition to costs resulting from each input increment and also estimate the increased production and its value. If the product is directly salable, as with animals in a feedlot, then the market price less the cost of marketing can be used. Where the product is not marketable in its present form, as in the case of fertilized forage being used for maintaining breeding cows, then the value of the forage can be estimated from alternative feed costs with appropriate adjustments for quality, location, form, and costs associated with making it available.

Fertilizing rangelands with nitrogen illustrates the nature of the analysis (table 8). Required information includes the increase in product (in this case weight gain in steer calves) for added increments of fertilizer, the cost of nitrogen applied, and the sale price of the animals.[40] In this example no allowance was made for value of fertilizer carryover and it was assumed that the grazing season was unchanged.[41]

It would be profitable under these conditions to apply 7,000 pounds of nitrogen to the 100-acre site. At this level of nitrogen application, the added cost of $130 for the seventh increment of 1,000 pounds of nitrogen fertilizer approximates the value added to the livestock product. At levels of nitrogen below 7,000 pounds, the value of the product added exceeds the additions to cost and for more than 7,000 pounds, the added costs exceed the value of the product added. With an increase in fertilizer cost and no change in livestock prices, the amount of fertilizer that should be applied would be less than 7,000 pounds.[42] With a decline in the cost of nitrogen,

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[40] If the quality of the salable product increases as well as the total gain, this relationship will be reflected in the price received.

[41] It was also implicitly assumed that the rancher can increase forage production by fertilizing range more cheaply than he can purchase feed from alternative sources.

[42] Assuming no carryover effects.

TABLE 8

Determining Most Profitable Level of Range Fertilization for a 100-Acre Site, Grazed 120 Days by 50-500 Pound Steer Calves

Ammonium sulfate	Added cost[a]	Gain per head per day	Total gain	Added beef	Value of product added[b]
pounds	dollars	pounds			dollars
0	--	.60	3,600	--	--
1,000	130	.88	5,280	1,680	336
2,000	130	1.13	6,780	1,500	300
3,000	130	1.36	8,160	1,380	276
4,000	130	1.57	9,420	1,260	252
5,000	130	1.77	10,620	1,200	240
6,000	130	1.95	11,700	1,080	216
7,000	130	2.06	12,360	660	132
8,000	130	2.10	12,600	240	60

a/ 12 cents per pound of fertilizer, plus an application cost of 1 cent per pound.

b/ Animals sold at end of grazing period for 20 cents per pound at site.

additional fertilizer could be profitably applied. Similarly, should the price of beef rise, the value of the product added would increase for each level of nitrogen fertilization and, therefore, it would pay the rancher to fertilize more heavily. The optimum level of fertilizer application (or the level of use of any other variable input) is guided by the physical response to the variable input factor, its cost per unit, and the corresponding changes in output and price received.[43] The nitrogen fertilization example illustrates the need for estimating returns as well as costs when evaluating range improvement practices.

Typically, alternative practices designed to accomplish a given goal lead to similar but not identical results. The approach to use in comparing practices producing slightly different results is illustrated by considering two methods of brush removal. Burning of brush will result in a complete clearing only under optimum conditions. If the brush is mashed mechanically before burning and allowing it to dry, the amount remaining after the fire is usually reduced but the cost of the operation is increased. Mechanical clearing and piling of the brush by bulldozing, and with subsequent burning of the dry piles, is still more costly but usually is more effective in clearing the site of woody vegetation. Since the results from each are different, the critical questions are: (1) what amounts and types of physical inputs does each practice require, (2) what is the least cost combination of inputs for each procedure, (3) what is the estimated cost associated with each practice per acre cleared, and (4) what are the anticipated results in terms of the elimination of brush and of seeding conditions if seeding is necessary. The fourth question requires an estimate of how long the results can be expected to last, of the timing and amount of reinvestment required, and of the additional cost if additional preparation must be undertaken before the area can be seeded.

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[43] If one or more of the variable inputs in a range improvement practice is in limited supply then the principle governing how far to carry a given range improvement practice must be revised. Generally, when any input such as capital or labor is in limited supply it becomes more profitable to use the restricted input in another use on the ranch before the point is reached for the single use where return in that use is just equal to its cost. The most profitable use of any input is determined by the level of return from each possible use.

Improvements Involving Time and Uncertainty

A definite answer to these questions is often impossible. There are many factors to consider and there are many uncertainties. Nevertheless, if a certain result is desired, a comparison of methods and costs must be made. A number of difficulties may be encountered in making exact estimates as illustrated in the following statements. For instance, when burning is incomplete, it is necessary[44] to undertake "spot" burning and costs are increased. Also establishing a stand of seeded range plants is often difficult. A recent study of seeding wheatland to grass in eastern Colorado indicated that, on the average, 50 percent of regrassed areas had to be seeded twice before a satisfactory stand could be established.[45] The rate of brush regrowth and its effect upon the timing of retreatment is another source of uncertainty. Errors in estimating livestock output or sale prices lead to errors in estimating returns. An allowance needs to be made for these and similar uncertainties.

Where the probability of success for a given range improvement practice is low, the rancher may wish to include the cost of repeating the practice or to use other forms of discounting to allow for uncertainty. For example, with a seeding failure the cost of seed and seeding might be doubled and income would be deferred over a longer period. An alternative approach is to use inflated costs and discounted prices. Some ranchers have a high risk aversion; other ranchers discount their expectations very little. A rancher with a high risk aversion would not give serious consideration to a range improvement program that did not have an exceptionally wide margin between expected cost and returns.

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[44] This statement recognizes that spot burning is, of course, discretionary. The justification for a complete burn depends on the rate of reinvasion of brush and the cost of the retreatments required.

[45] U. S. Agricultural Research Service, "Economic Possibilities of Seeding Wheatland to Grass in Eastern Colorado," ARS 43-54, February, 1958.

Like their attitude toward risk, ranchers' time preferences for money (or liquid assets) vary depending on their capital position, age, outlook on the future, investment opportunities, and many other factors. The reluctance of individuals to commit funds to long-term investments, thus foregoing other investment opportunities, is called time preference for money (or liquid assets).

Since time is a major consideration in a range improvement program, methods are needed to compare the present and future value of capital and income. To do this it is convenient to divide time into manageable segments. The planning period is used to designate the total time over which the range improvement program is to be in progress and during which its results will be forthcoming. In establishing a grass cover on a previously brush-infested range, a planning period of fifteen years may be appropriate to permit the treatment to be completed, the new cover to become established, and its production fully realized. For fertilizing a given site, the planning period might be as short as two years. With a practice such as cross-fencing a pasture, the period of establishment might be only one year, with a total planning period of ten years required to allow for changes in forage production resulting from better utilization practices.

The planning period divided into planning intervals. The planning interval is the time unit into which the various operations can be classed for purposes of estimating when investments will be made and when returns will be forthcoming. Typically, the planning interval for range improvement is the production year. The anticipated costs and returns for the range improvement program are scheduled within the planning intervals in developing the range improvement program. This procedure indicates the pattern of net capital flow into the improvement program and provides the basis for capital planning. It also facilitates consideration of the improvement programs as a part of the total ranch program. Alternative improvement programs can also be compared in detail.

Discounting reduces future values to a present value. That is, discounting estimated future returns to a present value indicates the amount of money that would have to be invested today to realize a given amount of total return at a future date. The discounting procedure can also be used to establish a rancher's preference for cash today as compared to cash in the future.

Either of two procedures can be used to determine the present value of future net incomes. One method discounts the net return for each year in the planning period and sums the annual discounted net returns. The second method discounts the costs and returns separately for each year, sums the cost and income streams separately, and then determines the discounted net return by taking the difference between the summed discounted cost and returns.[46]

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[46] $$PV_{NR} = \sum_{i=1}^{n} \frac{NR_i}{(1+d)^i}$$

where PV_{NR} = present value of the stream of net returns

NR_i = net return in year i

d = discount rate

$\sum_{i=1}^{n}$ = summation of discounted NR_i's from year 1 through n

Assuming a three-year program with expected costs and returns as follows:

Year	Cost	Gross return	Net return
1	$2,000	$ 3,000	$ 1,000
2	2,000	4,000	2,000
3	2,000	4,000	2,000
	$6,000	$11,000	$ 5,000

Footnote 46 continued on next pa

A comparison of alternative means of improving a range site illustrates the methods used in evaluating a series of practices. It also illustrates an appropriate treatment of the time problem. Three alternative techniques for improving a 500-acre sagebrush range are compared. This type of improvement and the data used are typical of spring-fall range revegetation on ranches in the Intermountain area of the west (table 9). Plan I provides for mechanical clearing of the 500-acre site and seeding to crested wheatgrass. The perimeter of the site is fenced and crossfencing is used to divide the improved area into three pastures. Brush regrowth is to be sprayed the third year. It is estimated that the entire program will have to be repeated in ten years. Thus during the first and eleventh years fall grazing is to be deferred.

Plan II is similar to Plan I except that the brush clearing is done by burning. Brush regrowth is to be sprayed twice--the second year and fifth year after burning. It is estimated that Plan II will have to be repeated, beginning the eleventh year. The clearing techniques used in Plan III are identical to those used in Plan II except that only half of the site is cleared and seeded at a time. The 500-acre site under Plan III is fenced

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Footnote 46 continued

Total sum of the net returns without discounting is $5,000. Discounting the net returns at a rate of five percent, the net returns are reduced to $4,494.

$$PV_{NR} = \frac{1,000}{(1+.05)} + \frac{2,000}{(1+.05)^2} + \frac{2,000}{(1+.05)^3}$$

$$= \$\ 952.40 + \$1,814.00 + \$1,727.71$$

$$= \$4,494$$

Net returns for each year were computed and then discounted and summed. Comparing the present value of $2,000 to be received in the second year with the same amount to be received in the third year illustrates clearly the decline in value of future earnings as the time period lengthens.

TABLE 9

Three Alternative Twenty-Year Improvement Plans for a 500-acre Sagebrush Range Site in the Intermountain Area a/

Practices and timing (planning intervals)	Plan I		Plan II		Plan III	
		dollars		dollars		dollars
Year 1						
Deferred grazing	125 AUM @ $4.00	500	125 AUM @ $4.00	500	62.5 AUM @ $4.00	250
Mechanical clearing	500 acres @ $7.00	3,500				
Seeding (drilled)	500 acres @ $4.25	2,125				
Fences and cross-fence	6 miles @ $500	3,000				
Year 2						
Deferred grazing	125 AUM @ $4.00	500	125 AUM @ $4.00	500	62.5 AUM @ $4.00	250
Fireline construction			4 miles @ $15.00	60	3 miles @ $15.00	45
Burning			500 acres @ $1.00	500	250 acres @ $1.00	250
Seeding (drilled)			500 acres @ $5.50	2,750	250 acres @ $5.50	1,375
Fences and cross-fence			6 miles @ $500	3,000	3 miles @ $500	1,500
Year 3						
Deferred grazing			125 AUM @ $4.00	500	62.5 AUM @ $4.00	250
Year 4						
Deferred grazing					62.5 AUM @ $4.00	250
Spray regrowth	500 acres @ $6.00	3,000	500 acres @ $6.00	3,000	250 acres @ $6.00	1,500
Year 5						
Deferred grazing					62.5 AUM @ $4.00	250
Fireline construction					3 miles @ $15.00	45
Burning					250 acres @ $1.00	250
Seeding (drilled)					250 acres @ $5.50	1,375
Fences and cross-fence					2 miles @ $500	1,000
Year 6						
Deferred grazing					62.5 AUM @ $4.00	250
Year 7						
Spray regrowths			500 acres @ $6.00	3,000	500 acres @ $6.00 (both fields)	3,000
Year 8						
Nominal maintenance						
Year 9						
Nominal maintenance						
Year 10						
Spray regrowth					250 acres @ $6.00	1,500
Year 11						
Deferred grazing	150 AUM @ $4.00	600				
Mechanical clearing	500 acres @ $7.00	3,500				
Seeding (drilled)	500 acres @ $4.25	2,225				
Year 12						
Deferred grazing	375 AUM @ $4.00	1,500	150 AUM @ $4.00	600	75 AUM @ $4.00	300
Fireline construction			4 miles @ $15.00	60	3 miles @ $15.00	45
Burning			500 acres @ $1.00	500	250 acres @ $1.00	250
Seeding (drilled)			500 acres @ $5.50	2,750	250 acres @ $5.50	1,375
Year 13						
Deferred grazing			375 AUM @ $4.00	1,500	187.5 AUM @ $4.00	750
Year 14						
Spray regrowth	500 acres @ $6.00	3,000	500 acres @ $6.00	3,000	250 acres @ $6.00	1,500
Year 15						
Deferred grazing					75 AUM @ $4.00	300
Fireline construction					3 miles @ $15.00	45
Burning					250 acres @ $1.00	250
Seeding (drilled)					250 acres @ $5.50	1,375
Year 16						
Deferred grazing					187.5 AUM @ $4.00	750
Year 17						
Spray regrowth			500 acres @ $6.00	3,000	500 acres @ $6.00 (both fields)	3,000
Year 18						
Nominal maintenance						
Year 19						
Nominal maintenance						
Year 20						
Spray regrowth					250 acres @ $6.00	1,500
TOTAL		23,450		25,220		24,780

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a/ Additional labor costs associated with increased numbers of livestock grazed have been omitted. It is assumed that the increased labor requirement can be met with existing permanent ranch help.

into two 250-acre pastures. Rented pasture is used during the deferment period for all plans.

Grazing capacity and gains per head are based on estimates derived from results of experiments that were conducted on similar improvements under similar conditions in southern Idaho. This site is estimated to have originally provided grazing for fifty 700-pound steers for six weeks in the spring, with gains of one pound per head per day, and for four weeks in the fall at 1/4 pound per head daily gain. After the site is improved it is expected to provide 45 days of grazing in late spring (approximately May 1 to June 15), and 30 days of grazing each fall (about September 15 to October 15). The estimated carrying capacity after improvement is 150 head of steers. Gains will vary with changes in forage conditions during the life of the improvement. The trend in gains per head is adjusted downward over the period to reflect a decline in productivity in forage between improvements.

Costs and returns for the three improvement programs by planning intervals are shown in table 10. Plan I is the most intensive program and demands the greatest capital outlay ($26,550) over the 20-year period. Furthermore, not until the seventh year following the initial investment is the cumulative return expected to exceed the cumulative cost. It is expected to be nine years before the cumulated net return on the improved range exceeds the cumulative net return from the same site unimproved. Yet, Plan I promises the greatest net return, if the rancher can meet the capital outlay of the first year. Plan I also provides for one more season of grazing since it is not necessary to produce an understory of grass[47] before initial clearing as is the case when the site is burned. The rancher does not have to locate an alternative grazing site for the additional year.

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[47] Resident grasses are considered to be sufficiently abundant to produce an adequate fuel to carry a fire.

TABLE 10

Costs and Returns for Three Alternative Twenty-Year Improvement Plans for a 500-acre Sagebrush Site in the Intermountain Area

Year	Return with no improvement	Plan I			Plan II			Plan III		
		Improvement cost	Return	Net	Improvement cost	Return	Net	Improvement cost	Return	Net
	dollars									
1	520	9,225	--	-9,225	500	--	- 500	250	--	- 250
2	520	500	--	- 500	6,810	--	-6,810	3,420	--	-3,420
3	520		2,043	2,043	3,500	--	-3,500	250	--	- 250
4	520	3,000	2,393	- 607		2,043	2,043	1,750	1,084	- 666
5	520		2,977	2,977		2,393	2,393	2,920	1,259	-1,661
6	520		2,977	2,977		2,977	2,977	250	1,551	1,301
7	520		2,977	2,977	3,000	2,977	- 23	3,000	2,510	- 490
8	520		2,744	2,744		2,977	2,977		2,685	2,685
9	520		2,393	2,393		2,744	2,744		2,860	2,860
10	520		1,810	1,810		2,393	2,393	1,500	2,685	1,185
11	520	6,325	1,576	-4,749		1,810	1,810		2,393	2,393
12	520	1,500	1,576	76	3,910	1,576	-2,334	1,920	2,160	240
13	520		2,043	2,043	1,500	1,576	76	750	1,985	1,235
14	520	3,000	2,393	- 607	3,000	2,043	- 957	1,500	1,926	426
15	520		2,977	2,977		2,393	2,393	1,970	1,985	15
16	520		2,977	2,977		2,977	2,977	1,500	2,277	777
17	520	3,000	2,977	- 23	3,000	2,977	- 23	3,000	2,510	- 490
18	520		2,744	2,744		2,977	2,977		2,685	2,685
19	520		2,393	2,393		2,744	2,744		2,860	2,860
20	520		1,810	1,810		2,393	2,393	1,500	2,685	1,185
TOTAL	10,400	26,550	43,780	17,230	25,220	41,970	16,750	25,480	38,100	12,620

Plan II requires approximately five percent less capital outlay over the 20-year period, but the total and net returns are less than for Plan I. Over the first three years the cash outlay is expected to exceed that of Plan I, and income is deferred for an additional year. In three years, the accumulated net return for Plan II is thus \$-10,810 while that of Plan I is \$-7,682.

By improving half of the site at a time (Plan III) the costs are spread more evenly over the period but they are slightly greater than for Plan II. Moreover, net income is reduced by more than \$4,000 as a result of the time lag in raising the productivity of the pasture.

While return over cost from the improvements indicate the profitability of the programs relative to the direct costs incurred, the true worth of the improvement to the ranch may not be fully reflected. What would have been earned had no improvement been made is often called the opportunity cost associated with the improvement program.

To reflect both the effect of time and opportunity cost, it is necessary to indicate the discounted values for each of the alternative improvement programs (table 11). Since the cash outlays for improvement are large in the initial years, and income is deferred, the discounting process substantially reduces net returns.

The basic thought in discounting is to find equivalent values that supposedly a rancher would be indifferent as to which he accepted and from which he can make comparisons of the values created with other opportunities for the use of his capital and more adequately evaluate the various rates at which the values are created. The undiscounted annual values in table 10 at a five percent discount and interest rate as shown in table 11. The present values of the accumulated sum of annual incomes are \$6,805 for Plan I, \$6,385 for Plan II, and \$4,853 for Plan III. Supposedly, a rancher would be

TABLE 11

Costs and Returns Discounted at the 5 Percent Rate for Three Alternative Twenty-Year Improvement Plans for a 500-Acre Sagebrush Range Site in Intermountain Area

Year	Return with no improvement	Plan I			Plan II			Plan III		
		Improvement cost	Return	Net	Improvement cost	Return	Net	Improvement cost	Return	Net
	dollars									
1	495	8,786	--	-8,786	476	--	- 476	238	--	- 238
2	472	454	--	- 454	6,177	--	-6,177	3,102	--	-3,102
3	449		1,765	1,765	3,023	--	-3,023	216	--	- 216
4	428	2,468	1,969	- 499		1,681	1,681	1,440	892	- 548
5	407		2,333	2,333		1,875	1,875	2,288	986	-1,301
6	388		2,221	2,221		2,221	2,221	187	1,157	971
7	370		2,116	2,116	2,132	2,116	- 16	2,132	1,784	- 348
8	352		1,857	1,857		2,015	2,015		1,817	1,817
9	335		1,543	1,543		1,769	1,769		1,844	1,844
10	319		1,111	1,111		1,469	1,469	921	1,648	727
11	304	3,698	921	-2,777		1,058	1,058		1,399	1,399
12	290	835	878	43	2,177	878	-1,299	1,069	1,203	134
13	276		1,083	1,083	795	836	40	398	1,053	655
14	263	1,515	1,209	- 307	1,515	1,032	- 483	758	973	215
15	250		1,432	1,432		1,151	1,151	948	955	7
16	238		1,364	1,364		1,364	1,364	687	1,043	356
17	227	1,309	1,299	- 10	1,309	1,299	- 10	1,309	1,095	- 214
18	216		1,140	1,140		1,237	1,237		1,116	1,116
19	206		947	947		1,086	1,086		1,132	1,132
20	196		682	682		902	902	565	1,012	447
TOTAL	6,481	19,065	25,870	6,805	17,604	23,989	6,385 (7,033)a/	16,258	21,109	4,853 (6,551)a/

a/ See explanation in the text for the derivation of the values shown in parentheses.

indifferent, using Plan III as an example, as to whether he received annual net income payments in the amounts indicated in the third column, Plan III, table 10, or received $4,853 at the present time, or received $12,876 20 years from now. This latter value is the sum of money that $4,853 will be at the end of 20 years at an interest rate of 5 percent. Should the rancher not consider the annual net income payment sequence acceptable, or should he be able to make a higher rate of return in other investment opportunities, he may question the advisability of improving his range.

Because of the timing sequence differences in the development of the three plans and, therefore, in the pattern of annual net revenues, the true net sum of total net returns for Plans II and III does not coincide exactly with the 20-year interval that has been used. Tables 10 and 11 merely indicate the results over a period of 20 years, which is the point in time at which reinvestment in Plan I must be repeated. Positive net returns accumulate in Plan II into the 21st year and to Plan III into the 26th year. When these time differences are taken into account, the accumulated annual net returns for Plan II are $7,033 and for Plan III they are $6,551.05 instead of the $6,385 and $4,853 as shown in the total row of table 11.

Returns can now be compared only by converting the annual net returns for each plan to a sequence of equal annual payments. This is done by converting the accumulated annual discounted net returns for each plan given in table 11 and above to a single rate of payment sequence by a procedure called amortization or the determination of an annuity the present value of which is known.[48] The equal payment sequence for Plan I is $545.87, for Plan II it is $548.56, and for Plan III $455.71. Plans I and II have an essentially equivalent rate of annual net returns and an essentially equivalent present value. Plan III does not yield as high a rate of annual net returns as Plans I and II but this plan also does not require as large average annual capital outlay.

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[48] The formula is: $\frac{a^{-1}}{n} = \frac{i}{1 - (1+i)^{-n}}$; the use of this formula places the "annuities" on an equal time interval basis.

Returns to capital investment are indicative of the relative profitability of the three programs and are an additional means of comparing different programs (table 12). Even under the more favorable price situation, Plan I yields a return of only two percent when opportunity costs are included. Thus, when time and the alternative of not improving the site are admitted for consideration the potential earnings are marginal. With beef at 15 cents per pound, none of the programs is profitable. The foregoing example was selected to illustrate the type of comparisons that can be made and to emphasize the need for caution in making them.

Most ranchers establish a program of range improvement that combines several practices. Usually several improvement practices and one or more utilization practices are used. Interactions may exist (1) between improvement practices when the inputs required to reach given ends change as combinations of practices change, (2) between utilization practices when the total production changes for one or more methods of range use when used in combination, and (3) between improvement and utilization practices when the inputs in improvement are related to inputs in utilization.

The competitive relationship is perhaps the interaction most frequently encountered. Competition, for example, between an improvement and utilization practice exists whenever it is necessary to defer grazing in order to provide sufficient grass cover to carry a fire. Competition between utilization practices frequently is associated with grazing cattle and sheep on the

TABLE 12

Comparative Returns on Investments in Three Range Improvement Programs for Two Selected Beef Price Levels

	Return on investment			
	Net discounted		Discounted at 5 percent rate	
Alternative plans and beef price levels	Cash basis	Net of opportunity cost	Cash basis	Net of opportunity cost
	percent			
Plan I				
20-cent beef	65	26	36	2
15-cent beef	24	-6	2	-24
Plan II				
20-cent beef	66	25	36	-1
15-cent beef	25	-6	2	-25
Plan III				
20-cent beef	50	9	30	-10
15-cent beef	12	-18	-3	-32

same site. The extent of the competition depends primarily on the nature of the plant community, the number of each type of livestock grazed and the season of use. Competition for alternative uses of capital and labor inputs may be encountered at any stage in range improvement, particularly when internal capital and labor resources are being used to carry on the improvement program.

Complementary relationships are important in the production or utilization processes because either total product may be increased as a result of using the processes together, or reductions in the inputs required to produce a quantity of product may become possible. For example, mechanical clearing as opposed to burning may decrease subsequent reseeding costs and, in some instances, increase the stand of forage.

For certain western ranges it is possible to increase the production of grass by grazing sheep seasonally on the competitive plants. Grazing of both sheep and cattle through better total utilization of the forage made possible by the differences in grazing habits, may result in a larger total product than grazing by either alone. Feed resources during the rest of the year and labor, management and building requirements for sheep and cattle are among major considerations influencing the profitability of sheep and cattle production on the same ranch.

Supplementary resource relationships exist whenever resources can be used in producing other enterprises or for other productive purposes without reducing their effectiveness in their principal use. By using tractors and other machinery during the summer for crop production and in other seasons for range improvement, the rancher can increase the use of the machinery, spread the overhead costs of ownership over more hours, and thereby reduce per-hour overhead costs.

Closely related to these interrelationships (and often confused with them) are secondary effects that accompany improvement practices under some conditions. These effects, which are usually not foreseen, may be rather significant. One common type, often emerging when woody growth is removed from an upland site, is the increased flow of water in streams or from springs. Even after other types of vegetation are established, the increased flow may continue and substantially improve the stock water conditions on the ranch. General improvement of watersheds through range revegetation is an important consideration in generating public interest in range improvement. Adverse effects must also be recognized. When the rancher fails to establish a plant cover on a site after removing the existing cover, erosion of top soil might occur.

Determining When to Reinvest in Range Improvement

Few improvement programs are of such a permanent nature that some reinvestment is not required. This is particularly true of revegetation practices. A reseeded site may produce much more forage than it would have produced if it had not been improved. But the production per acre on reseeded sites tends to decline after a period of years. As production decreases so does annual net return. Therefore, the rancher must decide when he should repeat all or part of the treatment. The decision is made on the basis of a comparison of expected profits from reinvestment with the income flow from his present program. As in previous examples, the comparison is made on expected net returns.

A simplified example will illustrate this type of comparison. Annual net returns for a given seeding are shown in column 2 of table 13. An income loss is incurred during the first years of the program since grazing must be deferred for a period of one to two years, and in some cases as much as three years. The income path follows the assumed forage production pattern.49/

49/ It should not be inferred that in all cases grazing rates are confined to what will be retained on the improved site indefinitely. Departures from these levels of grazing may be highly profitable, particularly where the opportunity exists to re-establish the seeding through additional capital investment. Neither is it to be inferred that excessive grazing of ranges subject to improvement is profitable.

TABLE 13

Determining Most Profitable Time to Reinvest in Range Revegetation a/

Year 1	Annual net returns 2	Accumulated net returns 3	Present value of net returns 4	Accumulated present value of net returns 5	Amortized present value of net returns 6
1	-375	-375	-357	-357	-375
2	-357	-732	-324	-681	-366
3	243	-489	210	-471	-173
4	554	65	456	- 15	- 4
5	723	788	567	552	128
6	783	1,571	584	1,136	224
7	825	2,396	586	1,722	298
8	834	3,230	564	2,286	354
9	830	4,060	535	2,821	398
10	792	4,852	486	3,307	428
11	761	5,613	445	3,752	452
12	732	6,345	408	4,160	469
13	694	7,039	368	4,528	482
14	667	7,706	337	4,865	491
15	632	8,338	304	5,169	498
16	607	8,945	278	5,447	502
17	573	9,518	250	5,697	505
18	531	10,049	221	5,918	506
19	510	10,559	202	6,120	507
20	480	11,039	181	6,301	505

a/ Net returns data based on research on range reseeding conducted in Idaho, California, and Colorado with appropriate adjustments for the grazing practices assumed. Computational methods followed were:

Column (4) $PV = \frac{NR}{(1+i)^n}$;

Column (6) equals values in Column (5) multiplied by the expression

$$\frac{i}{(1+i)^n-1}.$$

For purposes of illustrating the principles involved it is assumed that the prices of salable livestock remain fixed, that the original program was the most profitable, and will remain the most profitable. The flow of net return from reinvestment will then duplicate that of the original investment.

It is profitable to repeat the improvement program when the annual net return to the initial treatment (column 2, table 13) is equal to the highest amortized value of the accumulated net returns (column 6, table 13).

For the example used to construct table 13 the optimum reinvestment point is reached at the end of the 19th year. Reinvestment at the end of the 19th year would maximize annual net revenues for the initial treatment period and for each succeeding treatment period.[50] The principle is perhaps best understood when viewed as an annuity. Supposedly a rancher, who had the opportunity to receive a certain annual net revenue each year for a period of years, would be indifferent, in terms of its present value, as to whether he received: (1) an accumulated net return of $10,559 distributed in the manner indicated in column 3, table 13, (2) a lump sum payment of $6,120 now which represents the present value of the expected net returns for the 19 year period, or (3) an annual payment of $507 at the end of each year over the next 19 years. A five percent discount rate for time preference was used. A higher discount rate would extend the time interval, a lower discount rate would shorten the time interval.[51] This principle can also be stated in the following general form. If the original improvement program throughout its duration results in an increase in net return over the return to the unimproved site, it always will pay to reinvest in the improvement before production on the site falls to the original level.[52]

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[50] Provided the existing ratio between cost and price is maintained.

[51] The higher the discount rate on future income the greater is the preference for present income.

The conclusions drawn are represented in figure 2. The flow of income through time from the improved site is compared with the amortized present value of net returns and the income flow from the unimproved site. This figure depicts graphically the information contained in table 13, with the addition of the annual net returns from the site with no improvement.

Estimating future yields, prices, costs, and production patterns for long periods of time is extremely difficult. But these complications can be at least qualitatively incorporated into the evaluation process. For example, if the next treatment will bring about a greater net return per acre than the preceding treatment, the rancher will reinvest sooner. If his discount rate for time preference has shifted to a higher level, he will wait longer before reinvesting. An increase in improvement costs would reduce expected net returns from the next improvement and defer the next period of improvement. An increase in expected beef prices would have the opposite effect. If the rancher expected that an improved technique was to be available in the near future, he would probably want to delay the next treatment until the new practice or technique could be evaluated. While this type of analysis is subject to many uncertainties, it nevertheless provides an appropriate logic.

Impact of Range Improvement on the Entire Ranch Operation

Although the preceding examples of analysis of improvement practices have been presented as budgets of specific practice in order to explain the principles of choice among alternatives, a primary objective of this examination of the economic aspects of range improvement is to consider improved practices

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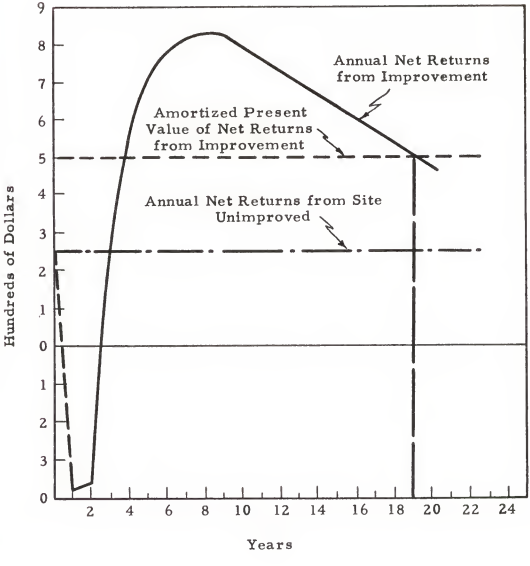
[52] The reasonableness of this statement is subject to the consideration that costs, prices, and physical relationships will change over time.

FIGURE 2

Determining the Most Profitable Time to Reinvest in Range Improvement Under Stated Conditions



in relation to the entire ranch operation. The answer to economic feasibility of range improvement depends upon isolating and relating to the ranch firm's entire sequence of operations the elements of the improvement programs that affect costs, production, and the prices received. The main concern of this section will be with the relation of specific practices to ranch feed requirements, more general ranch organization adjustments, and economic feasibility of practices for given conditions. The nature of the impact of range improvement is illustrated, first, in general terms to restate the nature of the influences of range improvement on the cost and returns and, second, in specific terms by means of a complete budget analysis of a range improvement program.

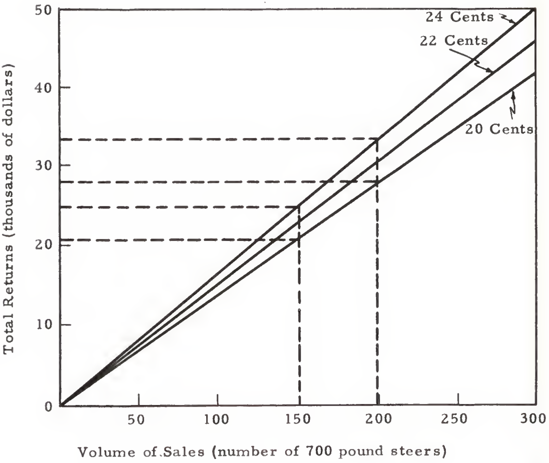
Range Improvement and Ranch Income

A change through range improvement in the total quantity of forage available, its nutrient content, its seasonal availability, or its effectiveness of use causes adjustments in other segments of the ranching operation. Cash expenditures for feed and labor and other factors affect variable costs, and investment in fencing and water development affects ranch overhead.

Figure 3 is used to illustrate a relationship between production, income, and price. Changes in total returns due to a price change can be determined from the appropriate total return line. For example, if the 700-pound feeder steers produced on a ranch can be increased from 150 to 200 head through range improvement and the selling price is 20 cents per pound, the total returns can be increased from $21,000 to $28,000. At 24 cents the increase would be $8,400, as contrasted with $7,000 with a selling price of 20 cents. If the improvement is merely cost-reducing, as in substituting cheaper range forage for some purchased hay, net returns will increase, but total returns will be unchanged.

FIGURE 3

Total Returns from Sale of Feeder Steers on a Western Ranch under Various Price Volume Conditions



The influence of range improvement on the cost structure of ranches is often less apparent. Generally, two types of costs are involved. First, variable costs, the costs which vary with production, may increase or decrease depending on the type and extent of improvement. Fixed costs, the costs which must be paid regardless of production, will usually be increased by range improvement because the practices require additional investments of capital. And range improvement may affect other production costs. If they increase forage production, reseeding or fertilization will usually require additional cattle to utilize the added feed. If this happens, an overall increase in forage production and a greater outlay for purchased feeds may be required.

Not all improvement practices cause an increase in total costs. Total variable costs may decrease more than fixed costs are increased. A range improvement permitting production of a given livestock product is represented in figure 4 by a shift from TVC_1 to TVC_2 for the same volume of sales. This type of improvement would permit production of the same quantity of livestock as before but at a lower total variable cost or greater amount of output for the same total variable cost. For example, with present feed sources 150 head can be brought to sales weight of 700 pounds for $16,000 (15.2 cents per pound).[53] An improvement program which allows the substitution of range forage for purchased feeds could reduce total variable expenses[54] to $14,000 (13.3 cents per pound). Or, for the same total variable cost, 180 steers of salable weight of 700 pounds could be raised.

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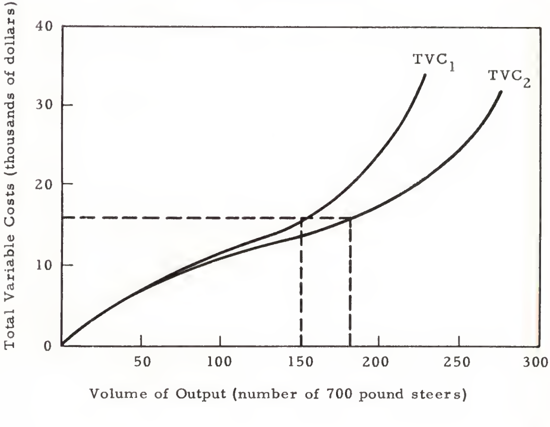
[53] Hypothetical.

[54] Figure 4 is based upon the assumption of a possibility for continuous substitution of range forage for purchased feeds.

FIGURE 4

Total Variable Costs for Producing Feeder Steers on a Western Ranch by Alternative Methods and for Various Numbers



However, other costs than variable costs must be considered. Depreciation and interest on the investment may increase. Another possible source of higher fixed costs is an increase in the size of the livestock operation. And if additional labor on a year-long basis is required the salary becomes an addition to fixed costs.

In the following illustration figure 5, total fixed costs for the ranch before improvement (TFC_1) are $2,000. As a result of improvement, total fixed costs (TFC_2) increase by $2,000 to $4,000 per year. Total costs (TC_1 and TC_2) are obtained by adding a fixed cost to the total variable costs of figure 4.[55] At low levels of output the added fixed costs due to improvement increase total costs above the cost for the unimproved range situation. As volume of production increases, the savings in variable expenses through substitution of improved range forage for purchased feeds, or better utilization of the other feed resources, results in lower total unit costs over a wide range of output.

How much output to produce is an important economic question. Since the difference between total costs and total returns represents the profit, the desired output level is that which results in the greatest difference between the two. For the unimproved range situation (figure 4) and with sales of 165 head, profit is $2,500 at a sales price of 20 cents per pound.[56] After an area of the range is improved the 165 head can be produced at greater profit but also additional profit can be achieved by increasing production. Total returns exceed the additions to total costs at each change in output up to 220 head of livestock and profit has been increased to $7,000 even though

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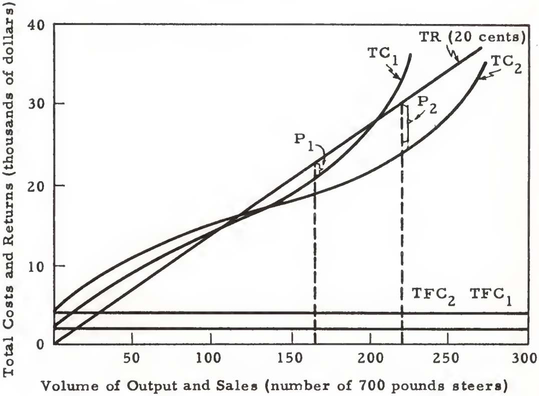
[55] The "typical" range improvement program for purposes of this discussion is one involving capital investment, thus increasing fixed costs, and a net reduction in total variable costs per head of livestock as numbers are increased.

[56] In economic terms, the marginal cost with respect to output is equated with the marginal return from the sale of that output. Graphically, the slopes of TC_1 and TR are equal at the most profitable level of output.

FIGURE 5

Comparative Costs, Returns and Profit Opportunities Under Unimproved and Improved Range Conditions on a Western Ranch



total cost has increased from $20,500 to $24,000. This comparison illustrates the possible relationship between improvement practices and a change in the size of the ranch operation.

Price is important in the relationship of range improvement to ranch income. Range improvement can give a ranch more flexibility if a wider profit margin is created. In the foregoing example, if price falls to 17.6 cents per pound, returns to the unimproved range just cover costs. Under the established improvement conditions, price can decline to 15.3 cents per pound before returns equal cost.

An Illustration Budget of Improving a Western Ranch

The ranch selected for budget analysis of range improvement is located in a typical sagebrush-grass range area.[57] The range, pasture, and hay land soils are of many types and without well-developed profiles. The alluvial fans, flood plains, and terraces have soils on which irrigated pastures and native grass can be produced. Some high quality hay and concentrates are purchased.

Shrubs, forbs, and native grasses are the three dominant plant groups and big sagebrush, rabbit brush, service berry, and bitter brush are the principal shrubs. Important forbs are arrowleaf balsam root, buckwheat, and sunflower. Blue bunch wheatgrass, Idaho fescue, Nevada bluegrass, cheatgrass, needle and thread, squirrel tail, and giant wild rye are the most common native grasses. Crested wheatgrass plantings have been successful.

Rainfall is in the 8 to 12 inch range and its seasonal distribution is highly irregular. Water for irrigation is obtained from rivers or from tributary streams. The season and duration of irrigation depends on the supply of water from accumulated snowfall and spring rains. The quantity of water usually limits the period of irrigation to about 30 days.

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[57] Basic information on feed requirements, land capacity, buildings, and equipment was provided by R. D. Lloyd, formerly Agricultural Economist, Farm Economics Division, Economic Research Service, U. S. Department of Agriculture, stationed at the University of Nevada, Reno.

Winter feeding is necessary. For a year-long production system, the amount of hay land and pasture determines the number of animal units that can be raised unless feed is purchased. The total number of animal units is also limited by the amount of range forage. Both private and federally owned ranges are used. Forest Service lands provide summer grazing and private range and the Bureau of Land Management lands provide spring-fall grazing. Livestock are removed from winter feeding about April 1 and turned out onto the ranges where they remain until fall. The close of the fall grazing period depends primarily on temperature, fall moisture, and snowfall. Generally, near the end of October the bulk of the livestock are moved onto pastures and hay lands. Market animals are brought in earlier, depending upon the marketing time and range condition.

The land and range resources of the ranch are suited to a cow-calf operation with approximately 300 cows in the breeding herd. A total land area of nearly 40,000 acres is required to carry the 375 cows and other livestock.[58] Federal lands comprise 86 percent of the total land area. The land resources, their productivity, and ownerships for this ranching operation are typical for ranches in the area. The investments in land and in livestock are approximately equal, and together represent more than 75 percent of the total assets of the ranching operation. Inventory values shown in table 14 on all depreciable items such as buildings, machinery, and equipment are the new cost in 1959 for each item, 50 percent depreciated.

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[58] Estimates provided by Lloyd, R. D., see footnote 57.

TABLE 14

Inventory, Investment, and Net Worth 375 Cow-Calf Ranch Intermountain Region, January 1, 1959

	Acres (number)	Value per acre [a] (dollars)	Total value (dollars)		
I. ASSETS					
1. Land (owned)					
Rangeland	4,800	6.00	28,800		
Pasture	290	60.00	17,400		
Hayland	470	75.00	35,250		
Farm lot	15	25.00	375	$ 81,825	
2. Land (grazing permit)	34,100[b]				
	An. units (number)	Av. value per head[c] (dollars)	Total value (dollars)		
3. Livestock					
Breeding herd					
mature cows, bred	300	115.00	34,500		
bred heifers, 2-3 years old	77	100.00	7,700		
heifers, 1-2 years old	80	76.00	6,080		
bulls	19	300.00	5,700		
Light calves	99	76.00	7,524		
Horses	5	185.00	925	$ 62,429	
4. Buildings and improvements				17,000[d]	
5. Machinery and equipment				9,100[e]	
6. Feed supplies					
Raised			3,200		
Purchased			2,194	$ 5,394	
TOTAL assets and investment					$175,748
II. LIABILITIES					
1. Accounts payable			2,194		
III. NET WORTH			173,554		
TOTAL liabilities and net worth					$175,748

[a] Market value, 1959.

[b] Based on a grazing permit of 3,410 animal units; grazing capacity is 10 acres per AUM.

[c] Average value for cows, bulls, and market value for replacements and calves.

$$\text{Average value} = \frac{\text{Value as a breeding animal + value of a cull cow (or bull)}}{2}$$

[d] 50 percent of 1959 new cost.

[e] 55 percent of 1959 new cost.

The feed requirements and the sources of feed are shown in table 15. These data have been determined from the number of cow units, breeding dates, calving percentage, replacement rate, and death loss. They indicate the acreages of range, pasture, and hay land needed to carry the number of livestock included in this operation. The total ranch income and expense budget in table 16 shows the expected net returns.[59]

The main ranching operations are: (1) feed production and procurement, (2) livestock production and management, (3) sales and purchases, and (4) repairs, maintenance, and construction of improvements. The feed requirements are governed by the number of animals, period of sales, and composition of the herd. Winter feeds are provided by a combination of ranch produced hay and purchased hay and concentrates.[60]

The total grazing period is about seven months, of which a month and a half of the forage requirement is provided by pasture and hay aftermath. Supplements and alfalfa hay are fed to calves, and occasionally to stock to be sold in the fall. Pregnant cows usually receive some supplements and native or improved grass hay in the late winter and early spring.

The spring grazing period begins about April 1 on owned range, the livestock are moved to federal range about April 15, and they are brought back to the headquarters area beginning about October 1. The animals to be sold are brought in first and the remainder of the herd is brought in shortly thereafter. Sales may take place in October, November, or December.

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[59] Sales prices per pound used in estimating income were: cows, 14 cents; bulls, 17 cents; yearling steers, 20 cents; yearling heifers, 18 cents; and 19 cents for all calves sold. All costs are based on 1959 cost levels. Livestock sales weights, replacement rates, and numbers carried over from year to year reflect typical practices followed by northern Nevada ranchers.

[60] A 105-day winter feeding period was assumed for this example.

TABLE 15

Feed Value and Forage and Feed Use
375 Cow-Calf Ranch, Intermountain Region, 1959

Kind of feed	Amount fed	Cost per unit	Total value
		dollars	dollars
Native and improved grass hay (tons)	470	8.00[a]	3,760
Alfalfa hay (tons)	104	20.00	2,080
Feed grains (hundredweight)	188	2.00	376
Salt (hundredweight)	124	2.15	267
Total			6,438

Forage and feed requirement, source, and use	Acres	Animal unit months
Forage		
On owned land		
Rangeland	4,800	480
Irrigated pasture	288	900
Hay land aftermath	470	470
On federal rangeland	34,410	3,410
Total forage	39,658	5,260
Feed		
Raised and purchased		1,744
Total forage and feed		7,004

[a] Ranch-raised hay, valued at $8.00 a ton.

TABLE 16

Income and Expenses, 375 Cow-Calf Ranch, Intermountain Region, 1959

	Animals	Weight per animal	Price per pound	Total value a/
	number	pounds	dollars	
Sales				
Cows	64	900	0.14	8,064
Bulls	6	1,200	0.17	1,309
Yearlings				
Steers	48	600	0.20	5,760
Heifers	48	575	0.18	4,968
Calves (steers)	140	400	0.19	10,640
TOTAL				30,741
Expenses				
Cash operating expenses				
Repairs--machinery and equipment				720
Labor--hired				2,750
Feeds purchased				2,740
Fuel, oil, grease				770
Veterinary--supplies and service				570
Salt				270
Grazing fees				750
Water				135
Electricity and telephone				173
Social Security				233
Other supplies				75
Interest on operating capital (6 percent for 6 months)				347
Sub-total				9,533
Cash and non-cash fixed expenses				
Depreciation				
Buildings and equipment				2,650
Livestock				2,050
Taxes				1,350
Repairs and improvements: fences and buildings				920
Insurance				440
Death loss (bulls)				170
Sub-total				7,580
TOTAL				17,113
Net ranch income and return to investment and management				
Total income				30,741
Total expense				17,113
Net ranch income				13,628
Unpaid operator and family labor				3,300
Return to investment and management				10,328

a/ Rounded to nearest dollar.

The hay land yields one ton of native grass hay per acre. Irrigated pasture provides three animal unit months of feed per acre and native range one animal unit month of feed for each ten acres of rangeland area. Each animal unit month of feed from federally-owned range costs about 22 cents.[61]

Stock cattle are maintained on native hay throughout the winter. The bull herd and horses are maintained on pasture--the bulls until June and the horses throughout the grazing period. Heavier feeding of bulls is begun about a month to six weeks prior to the breeding season.

The bulls are placed with the mature cows and heifers to be bred in June and remain with them until fall. At that time they are separated from the rest of the cattle and placed on pasture until the next June. When the cattle are moved to the range areas they are branded, sprayed or dipped, and vaccinated. Further insect control may be necessary at intervals during the late spring and during the summer.

Cows are kept in the breeding herd an average of five years and bulls for three years. Since replacement heifers are bred to calve at about three years of age, culled cows average eight years of age. The calving percentage used was 85 percent net calves weaned, and death loss was estimated at 3 percent for all other classes of cattle.

Prior to sales, cows are culled, the bulls to be sold are selected, and the replacement calves are chosen. Light weight calves--calves born in the late spring--are held over to be sold as long yearlings the following fall. About 70 percent of the calves are born before June 1 and 30 percent are born after June. This latter group of calves make up the bulk of the "held over" calves.

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[61] Taxes and interest on investment in private range increases the cost per AUM for range feed to about 50 percent above charges for equivalent feed from federal lands.

The ranch buildings consist of a stock shelter, a repair shop, a feed storage building, and a bunk house. Other improvements are a corral, fences, chutes, a well and pump, irrigation structures, and self-feeder bunks for concentrates. The hay is fed on the ground. The machinery and equipment consists of repair shop tools, haying equipment, a pickup truck, a horse trailer, stock water facilities, a spray unit, plows and ditching equipment, and the usual assortment of saddles, harnesses, ropes, branding and vaccinating equipment, and other items normally found on each ranch.

Planning and Budgeting

Planning is considering how the ranch will be operated. Plans are made on a weekly, monthly, annual, or longer term basis. Some marketing or production questions are simple and require little in the way of new information or in the way of detailed consideration. Other questions may involve major aspects of the ranching operation, they may require major adjustments in the forage and feed procurement program, or in the livestock system. Decisions about questions of this type require more detail in planning and more orderly consideration. Informal or formal budgeting is a convenient and adaptable means of organizing, and recording the detailed facts and ideas concerning income and expenses of plans. The ranch plan or budget may include only a part of the total operation, such as when a rancher wants to determine whether it is less expensive to purchase hay than to raise his own hay. Or a budget may include all of the ranch resources as is required when a new livestock system or way of producing livestock is to be substituted for the system presently used.

At the beginning of each production year the ranch operator normally examines the past year's record of income and expenses and attempts to determine if there is any way of increasing his income. He may question the expenditures for purchased feed. He may consider ways of reducing the hired labor. Excessive death loss may warn him of the need for changes in management practices. The size of the calf crop, weaning weights, and rates of gain are also important.

After considering alternatives such as changing management practices to reduce the amount of supplemental and winter feeding and to improve the productivity of some of his range, he decides to consider the feasibility of improving a portion of the spring-fall rangeland. This step involves clearing and seeding a site to be selected on the basis of location, soil, and topography. Fencing and stock water development also needs to be considered. He selects this program because it promises to increase the gains of the yearlings in the spring and fall grazing periods, to reduce the grazing intensity on the remaining acreage of owned range, and to decrease the length of the winter feeding period for these animals by approximately ten days.

But before investing capital in such a program he decides to estimate its potential effect on net ranch income. The 96 long yearlings will be grazed on the improved site for 21 days in spring and fall. The carrying capacity of the site in its unimproved condition is 1 animal unit[62] per 10 acres for 15 days in the spring and in the fall. After improvement it is estimated that 3.3 acres will provide grazing for 1 animal unit for 21 days in each period. Approximately 240 acres will need to be improved to provide this amount of additional forage for the 96 animal units. By concentrating the long yearlings on the improved range the grazing rate on the remaining spring-fall range can be reduced from 10 acres per animal unit month to 12 acres per animal unit month.[63]

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[62] An animal unit is a mature animal or the equivalent.

[63] Following the period of deferment of the reseeded acreage.

The present weight gains per head are 1 pound and one-fourth of a pound per day in the spring and fall periods respectively. After the range is improved it is estimated that the average gain will be 1.34 pounds in the spring and .4 pounds in the fall.[64] Earlier green feed is expected to reduce alfalfa hay feeding by 5 pounds per head per day for 10 days, saving 2.4 tons of purchased hay each year after the third year. It is estimated that three miles of fence will be needed and that a reservoir to collect water for the livestock must be built. Estimates of expenses and of the addition to receipts are shown in table 17.

This analysis indicates the discounted net returns from the improvement over its estimated 10-year life to be approximately $1,850.[65] The estimated 11 percent annual rate of return on the investment in the program over the 10-year period is nearly twice the rate of return to the present operation. The initial investment [66] is likely to be fully recovered by the sixth year.

The rancher is also interested in the effect this program may have on other aspects of his operations. First, the expected gross income from the sale of cattle is increased each year beginning three years after the improvement is made, the amount varying between $525 and $900, depending on the year. This increase is the value of the anticipated increase in beef production less opportunity costs (which are the present returns from the site to be improved). The variable costs are increased in the first two years by the rental of "outside" range but decline in the subsequent eight years because of reduced hay purchases. Small additions to variable costs which might arise from

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64/ Spring gains per day are estimated to be 1.5 pounds in the third year, to reach a peak of 1.9 pounds in the fifth through seventh years, and to decline to 1.3 pounds in the tenth year. Fall gains in the corresponding years of the program are estimated at 0.4, 0.7, and 0.3 pounds respectively.

65/ A sales price of 19 cents per pound and a discount rate of five percent were used and a change was made for the deferred grazing period.

66/ Fencing accounts for half the estimated cost.

TABLE 17

Budgeted Costs and Returns from Improving 240 Acres of Spring-Fall Range on a 375 Cow-Calf Ranching Operation

Year after improvement	Practices	Cash expenditures(+) or savings(-)	Returns on unimproved site: Beef production	Returns on unimproved site: Value	Returns on improved site: Beef production	Returns on improved site: Value	Returns net of expenses and opportunity costs	Discounted net returns
		(dollars)	(pounds)	(dollars)	(pounds)	(dollars)	(dollars)	(dollars)
1	Deferred fall grazing, 12 AUM @ $1.50	18			360[a] 90[b]	68 17		
	Disking and seeding, 240 acres @ $5.25	1,260					-2,778	-2,646
	Fencing, 3 miles @ $500	1,500	450	85				
2	Deferred spring-fall grazing, 24 AUM @ $1.50	36			450[b]	85	- 286	- 259
	Constructing stock water pond	250	450	85				
3	Reduced hay feeding, 2.4 tons @ $20	- 48	450	85	3,830	728	691	597
4	"	- 48	450	85	4,435	843	806	663
5	"	- 48	450	85	5,242	996	959	751
6	"	- 48	450	85	5,242	996	959	716
7	"	- 48	450	85	5,242	996	959	682
8	"	- 48	450	85	4,435	843	806	545
9	"	- 48	450	85	3,830	728	691	445
10	"	- 48	450	85	3,226	613	576	354
TOTAL		2,680	4,500	850	36,382	6,913	3,383	1,848

[a] Spring grazing completed before improvement program started.

[b] Production on rented pasture.

repair costs on the new fence within the 10-year period are not included in table 17.

The cost of disking and seeding needs to be recovered in the 10-year estimated life of the stand at the rate of $126 per year. A typical 30-year depreciation period for the fence would result in an annual cost of $50. The stock water pond is expected to last 10 years and its value is depreciated at an annual rate of $25.

The estimated effect of the improvement program, expressed as a rate of return to net worth, is shown in table 18. The rate of return increases from the present 5.9 percent to 6.3 percent during the highest production period and declines to 6.1 percent at the end of the 10 years.67/

In the preceding budgets, future production, prices, and costs were treated as if they were certain. Budget analysis is typically conducted in this manner, with allowances for uncertainty introduced at the time the results are being examined. For example, before putting the above improvement program into operation the ranch operator would determine the effect that different sales prices would have. For instance, if the program is profitable when beef sells for 19 cents per pound, is it still profitable when beef sells for 15 cents per pound? If so, the effect of a faulty price assumption would be

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67/ In addition to the increased income, the range improvement program may add to the stability of the ranch production and income. The added profit margin because of cheaper gains during the spring and fall periods adds to the ranch's ability to withstand lower prices.

Added flexibility, though difficult to evaluate, is also achieved. Some of the production from the seeded area can be cut for hay if the need arises in any given year. Greater spring-fall feed supply is available in the event production of native ranges is low in any given year. Though gains on yearlings might be reduced, more animals could be placed on the improved site in an emergency.

TABLE 18

Budgeted Net Effects of Range Improvement Program on Net Worth, Net Ranch Income and Return to Net Worth and Management by Years

Year	Net worth a/	Net ranch income b/	Return to management and net worth c/	Rate of return on net worth d/
	dollars			percent
Before improvement	173,748	13,628	10,328	5.90
After improvement				
1	176,508	13,587	10,287	5.83
2	176,307	13,368	10,068	5.70
3	176,154	14,059	10,759	6.10
4	175,953	14,174	10,874	6.18
5	175,752	14,327	11,027	6.27
6	175,551	14,327	11,027	6.28
7	175,350	14,327	11,027	6.29
8	175,149	14,174	10,874	6.21
9	174,948	14,059	10,759	6.15
10	174,747	13,944	10,644	6.09

a/ Total assets less total liabilities allowing for increased asset value from range improvement and decreased liabilities resulting from reduced hay purchases. Interest paid was deducted.

b/ Includes allowance for changes in fixed and variable costs resulting from the improvement program and differences in sales resulting from increases in sales. Annual values are not discounted for risk or opportunity cost.

c/ Net ranch income less operator's labor and unpaid family labor.

d/ Return to management and net worth expressed as a percentage of net worth.

diminished. In the program as planned, if the realized price were 15 cents rather than 19 cents, the return net of expenses and opportunity costs would still exceed $1,900.[68] Variations in forage yields that could be caused by adverse climatic conditions can also be evaluated as to their cost and income effect. Similar comparisons can be made using other factors which affect production or income.

Broader Economic Considerations and Range Improvement

The preceding discussion of range improvement has been along two distinct but related lines. The discussion of evaluation of specific practices was mainly concerned with physical input and output estimates, technical efficiency, and cost minimization. The discussion of the relation of range improvement to the feed and forage problems of livestock ranching was mainly concerned with organization, adjustment, and economic feasibility of range improvement for given conditions. A third area of consideration, and one which parallels these two lines of discussion, is changes in economic conditions and institutional or policy conditions which would affect price, cost, and the use that can be made of federal grazing lands. Other factors of a general nature which affect returns are taxes, service charges, competing uses for ranch input requirements--labor particularly, and the structure of land values. In addition to increased competition in the principal livestock markets, the western producer also faces increasing competition in the factor markets for his input requirements. The labor wage structure has changed materially, and the labor supply has been diminished by competition from industry and from other types of agriculture.

Reference has been made to the prospects for an increase in total demand for livestock products over future years. In meeting this increase in demand, western ranchers would compete with livestock producers in the Great Plains, the Corn Belt states, and the south. To insure a proportionate share of the livestock marketings, western livestock producers need to maintain their position as the major producers of feeders as well as the primary producers of slaughter animals. This means an increase in livestock numbers in the west, which in turn, means a continuation of the current upward trend in the adoption of range improvement technology and proper range forage utilization practices.

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[68] These conclusions would not necessarily hold for a stocker operation.

Under the conditions of static assumptions about price, cost, and production coefficients, range improvement and forage utilization decisions are primarily concerned with what practice to select. As these assumptions are relaxed, the decisions need also to take into account when the selected practice should be initiated. Under some circumstances a rancher may have considerable discretion as to timing. But under other circumstances, he would have little discretion as to timing, as when a change in public land policy forces an adjustment. A multitude of possibilities can exist; important ones are price trends and the livestock price cycle, trends in weather, income and real estate taxes and depreciation allowances, the availability of capital and of ACP and other types of payments, and the trend in competition for input factors and rangeland resource use.

The changes in wage rates and labor supply are indicative of the type of competition for production factors which is bringing about marked changes in management practices and in ranch organization. Substitution of fencing for herding of range sheep has had far-reaching effects. Tenure security on public range and equity in private property influence the willingness of ranchers to invest in range improvement on public and on private property. More investments will be made during high income years and during years in which livestock prices are rising. Income taxes during high income years and depreciation allowances on conservation and range improvement investments affect the expansion or contraction patterns of investments. The timing of investment is related to anticipated weather conditions because they affect risk in investment in range improvement and distribution of returns and cost over time. Future price expectations also have an important influence on the timing of decisions. Investments made at the beginning of a period of increasing prices pay out better than investments made at other times.

When livestock prices are low or when a period of drought develops,the supply of investment capital either is reduced or it is available only at a greater cost. Forage values are also low so that investment during these periods are related to risk and associated with expectations about price and weather in the immediate future. The cost sharing provisions of federal conservation programs may be the major inducement to improving the ranges during such periods. The programs of management and improvement of public range land have occasioned production adjustment and induced private range land improvement through need of the rancher to provide other sources of forage and through helping to demonstrate the practicality of range improvement.

While our criteria for choosing range improvement programs have been based on a comparison of income and costs created within a given ranch situation, a rancher will consider more than economic values.

The value systems or goals of ranchers may cause decisions which are inconsistent with optimum profits. A desire for profit or a desire to maximize income is often not the primary objective. And the uncertainties of climatic conditions and of economic processes are known to affect outcomes adversely. Therefore, decisions on the selection and the timing of improvement practices are affected accordingly. But, in general, choices are made on the basis of input factors which have a fairly predictable relationship to a specific outcome, even though information is incomplete and the risk is not precisely known.

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